Ashgill Brachiopoda from the Glyn Ceiriog District, north Wales

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Synopsis

The Ashgill age of the rocks of the Glyn Ceiriog district was first established in 1908 by Groom and Lake, who also reported the large shelly fauna. A more precise age has never been determined and with this objective the fauna has been revised in light of other recent work on the Ashgill. Sixty-seven brachiopod species including four new species, *Platystrophia anomala*, *Strophomena ceiriogensis*, *Katastrophomena dolhirensis* and *Mjoesina marri*, and two new subspecies, *Platystrophia lutkevichi costellata* and *Ravozetina rava prima*, are here described, and referred to sixty genera. It has been possible to date the Glyn Valley Group, comprising the older Dolhir and younger Glyn Formations, as ranging in age from top Cautleyan, through Rawtheyan, to Hirnantian. Close correlation has been established with rocks in the neighbouring inliers of Cyrn-y-brain and Mynydd Cricor, from which brachiopods are also described.

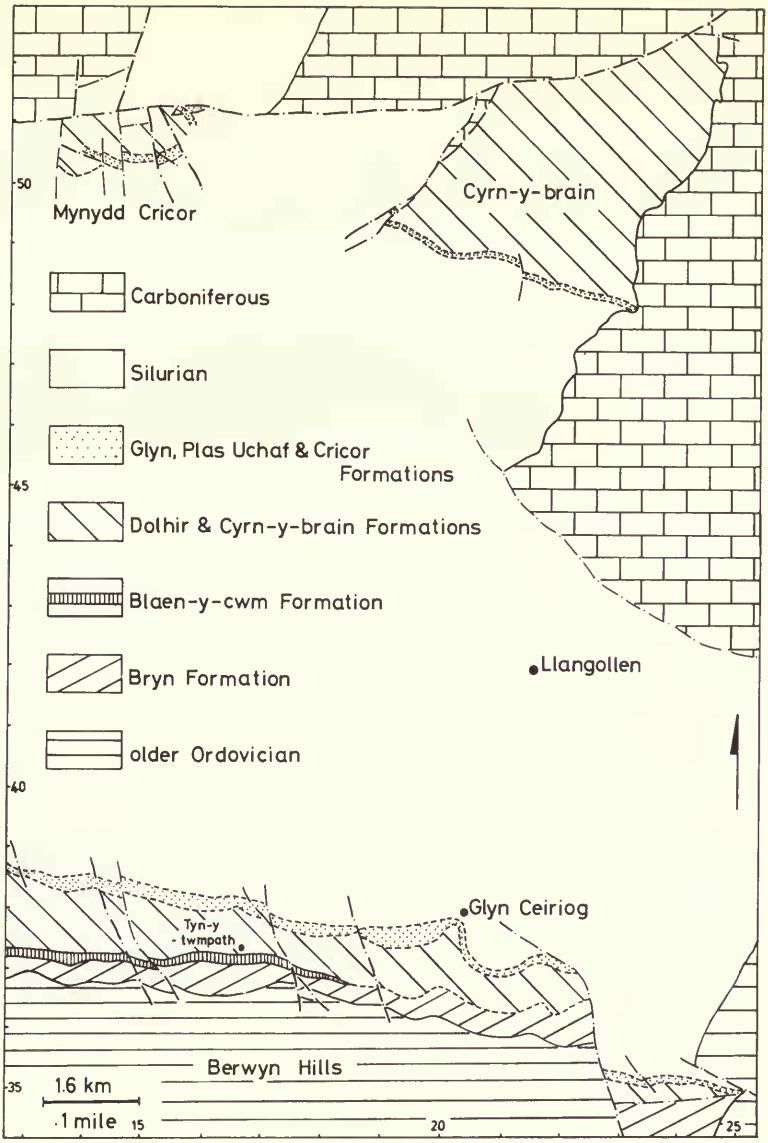


Fig. 1 Geological map of the Llangollen district.

Introduction

The present work comprises a study of the Ashgill brachiopods of the Glyn Ceiriog district, which lies in the north-eastern part of the Berwyn Hills, south of Llangollen, and those collected from the small inliers of Cyrn-y-brain and Mynydd Cricor a short distance to the north (Fig. 1). The earliest known account of the geology of the Glyn Ceiriog district is to be found in Bowmann's paper (1841). Its chief concern is the Silurian rocks of the Vale of Llangollen, but it includes a description of the igneous rocks cropping out along the River Ceiriog. Sedgwick recognized three main divisions in the rocks of the Ceiriog Valley (1845: 14): a lower group, containing some fossils; a middle group consisting of 'a great series of beds full of fossils' which alternate with several bands of volcanic rock; and a thick upper group, whose outcrop is about one mile wide, composed of calcareous slates with two bands of limestone. He concluded (p. 15) that this upper

group was stratigraphically far above the horizon of the 'Bala' Limestone (the Cymerig Limestone of modern usage), although at this time he regarded the Rhiwlas Limestone as being older than the 'Bala' Limestone (p. 7). He also recognized that the inliers of Cyrn-y-brain and Cricor Mawr (Mynydd Cricor) were older than surrounding rocks and the same age as those at Glyn Ceiriog. Davies (1872: 300) disagreed with Sedgwick in that he equated the limestone at the base of the Dolhir Formation with the 'Bala' Limestone and the limestone in the Glyn Formation with the Hirnant Limestone.

Groom and Lake published their account of the local geology in 1908 and the succession they produced is still in current use with only minor modifications. Groom and Lake included large faunal lists for the different horizons and it was they who first established an Ashgill age for the two formations on which the present study is focussed. The connection between the Glyn Ceiriog area and the inliers of Mynydd Cricor and Cyrn-y-brain was confirmed by Wills and Smith (1922) and also by Wedd *et al.* (1927).

Stratigraphy

The lithological units referred to in this paper are the same as those used in Wedd *et al.* (1927) and remapping did not reveal the need for any major stratigraphical revision. However, the terminology is brought into line here with the I.U.G.S. code for stratigraphical nomenclature. Thus the Ashgill rocks of the Glyn Ceiriog area belong to the Glyn Valley Group which can be divided into the Dolhir Formation, in which the laterally equivalent, basal, Tyn-y-twmpath and Dolhir Limestone Members can be recognized, and the Glyn Formation, including the Glyn Limestone Member. In both inliers to the north the Cyrn-y-brain Formation is the equivalent of the Dolhir Formation, while the Glyn Formation is represented on Cyrn-y-brain by the Plas Uchaf Formation and by the Cricor Formation on Mynydd Cricor.

In the Ceiriog Valley, the Dolhir Formation consists of about 475 m of cleaved micaceous siltstones and mudstones with subsidiary sandstone and limestone bands, all a characteristic blue colour. It rests unconformably on Bryn Formation siltstones which have been dated as Lower Longvillian (Brenchley 1965: 38, 40) or topmost Soudleyan (Bancroft 1945: 245) in age, and at its base is a 60 m thick series of beds of a distinctly calcareous nature (Dolhir Limestone Member), including a 10 m thick band of limestone which was once quarried at two localities. About 3·5 km to the west, in the valley of Nant Tyn-y-twmpath, no such calcareous beds are to be found, instead the first 70 m of the Dolhir Formation consist of highly cleaved, fissile mudstones (Tyn-y-twmpath Member), and these rest, not on Bryn Formation siltstones but on blue-black pyritous shales of the Blaen-y-cwm Formation. This is reported to contain poorly preserved graptolites (Groom & Lake 1908: 570; Wills & Smith 1922: 183) of a *Pleurograptus linearis* zone age (Wills & Smith 1922: 186). Therefore one hiatus exists between the Blaen-y-cwm Formation and the underlying Bryn Formation and another between the Blaen-y-cwm Formation and the Dolhir Formation, which to the east oversteps the Blaen-y-cwm Formation to rest on the Bryn Formation. (Fig. 2).

The Dolhir Formation contains a large and varied fauna in which brachiopods are the dominant element, but trilobites, ostracodes, bryozoa, gastropods, bivalves, cystoids, corals, crinoids and nautiloids are also present but in lesser numbers. The beds are fossiliferous throughout the formation but a particular band, about 50 m thick, immediately above the Tyn-y-twmpath and Dolhir Limestone Members, is especially rich in organic remains.

The Glyn Formation is composed of about 40 m of fine to coarse grained, buff-coloured sandstones with thin siltstones and a locally developed limestone member (Glyn Limestone) at the base on Mynydd Fron Frys. The formation is conformable on the Dolhir Formation which grades up into it. Fossils are common in the lower part, especially in rottenstone bands and lenses associated with the Glyn Limestone, but towards the top of the formation fossil remains are much rarer and the beds yield only the occasional brachiopod or small solitary coral. Across the whole area the Glyn Formation is conformably overlain by greenish-grey, cleaved mudstones and thin grey sandstones of the Fron Frys Formation. A poorly preserved shelly fauna dates this as being of Lower Llandovery age.

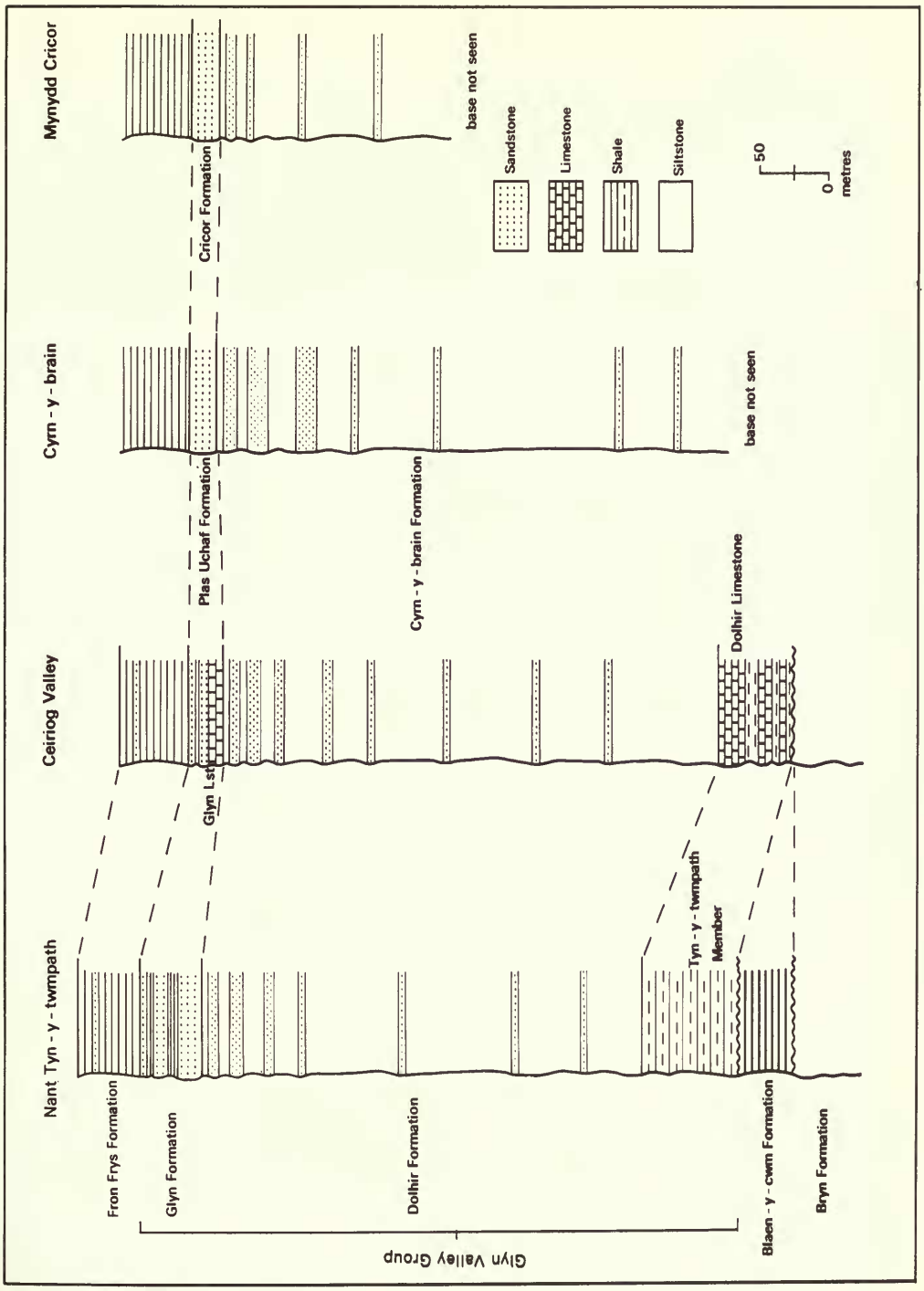


Fig. 2 Chart showing the correlation between the Ashgill formations of the areas studied.

Table 1 The number of pedicle, brachial or conjoined valves recovered from the various localities throughout the succession.

Locality	T	L							D														C					M		G				P
Species	1	2	3	1	2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	1	2	3	4	5	6	7	1	2	1	2	3	4	5	6	1
Catazyga cf. *headi*	31																																				
Chonetoidea cf. *papillosa*	1								4																												
Glyptorthis cf. *maritima*	3			5		2	4	4	1	2	15			1																						
Katastrophomena dolhirensis		2		8		2	3		6	12	24																									
Kullervo complectens albida	1			1					3		2									1																
Laticrura cf. *erecta*	1			8		1			12	12	3	3								2																
Leangella cf. *scissa*	1		1	1			3		5	1	1									1																
Leptaena cf. *rugosa*	2	1			1	1	7		3	2	26	1		1			5	2		22			5								2					
Lingulella sp. *B.*	1																																				
Nicolella actoniae	5			6			2	3	15	9	2			1			2			1										2		1				
Orthambonites cf. *humilidorsatus*	7			1				1		3	1									1																
Oxoplecia cf. *plicata*	1					1			3		12									2			1													
Platystrophia anomala	7			6			1		20	20	22	4	4	1							3															
Porambonites sp.	5																																				
Reuschella sp.	7			1						1								1																		
Sampo cf. *ruralis*		1				1			2	1	8	2																			1		1			
Sowerbyella cf. *sladensis*	1	2		1		1	1	1	25	23	8			3	1	2	8	1	8	8	32		4	1	6				6	14	5	34	10	1	2	1
Spinorthis geniculata	3		1	1																																
Strophomena ceiriogensis	5	1		1				2		2	12						1	2		1			3	1												
Triplesia cf. *insularis*	5			2			1	1	6	2	39		1			3				8	1									3						
Dolerorthis aff. *intercostata*				2		1	3		4		3		1							1	2							1								
Eremotrema cf. *paucicostellatum*				1			2		7	8	5									1																
?*Limbimurina* sp.				1																																
Skenidioides cf. *asteroideus*				1			9	11	26	17	1		1	1	1			1		1											4					
Spiriferide gen. et sp. indet.				1																																
Catazyga cf. *hicksi*								1			2																									
Christiania sp.									1	4	5		1	1																						
Cremnorthis sp.										2																										
Cryptothyrella crassa incipiens																				1		2	9	19	7	19										
Cyclospira sp.											1																									
Dalmanella cf. *testudinaria*								1			4							3	13		1		1			1				1	1	8	2			

Diambonia cf. *gibbosa*														1	4										7					
Dicoelosia cf. *indenta*	1					20		5				1	2	14	2											1					
Dicoelosia sp.	1				3	5																									
Fardenia scotica												2	3		1		1	1	2												
Gunnarella sp.			1																												
?*Howellites* sp.	6	2				8			3	2																					
Kjaerina sp.			6																												
?*Kozlowskites* sp.					1	1																									
Kullervo sp.															1																
Leptaenid gen et. sp. indet.															1																
Lingulella sp. *A*.		4				3																									
?*Luhaia* sp.															1												1				
Mjoesina marri															4							9									
Paracraniops sp.	2				1	3																									
?*Parastrophina* sp.															2																
Philhedra cf. *grayii*		1				1																									
Plaesiomys porcata		1		2	1	1		1							4	2		1	2				1				2	4			
Plectatrypa cf. *sulevi*														1																	
Portranella sp.		2	2												1			1													
Protozyga cf. *perplexa*						11																									
Ravozetina silvicola prima	1			35	37	2																									
Saukrodictya hibernica			1																												
Triplesiid gen. et sp. indet.															1																
Vellamo cf. *diversa*						1									4			7								1	1	2			
?*Dalmanella* sp.																	3														
Eoplectodonta sp.																		1									10				
Eostropheodonta hirnantensis																			14								1				1
Epitomyonia sp.																			3												
Platystrophia lutkevichi costellata																		7	4												
Plectatrypa cf. *gaspeensis*																		2						2							
Schizophorella cf. *fallax silicis*																		3	1							1		6			
Eodinobolus sp.																												1			
Hesperorthis sp.																											15		1		
Hirnantia sagittifera?																											7	1			3
Ptychopleurella sp.																										2					
Cliftonia sp.																															1

In the inliers to the north, the Dolhir Formation is represented by the coarser grained Cyrn-y-brain Formation, comprising over 500 m of tough, cleaved, blue siltstones and sandstones, the base of which is never exposed. The beds are locally very fossiliferous. On Cyrn-y-brain, the Plas Uchaf Formation, with a total thickness of about 15 m, rests conformably on the Cyrn-y-brain Formation and can be divided into three members. A massive, cleaved, coarse grained sandstone, 6 m thick, is succeeded by 5 m of platey-bedded muddy siltstone which is overlain by brown weathering, dark, blue grey sandy mudstone. Fossils are rare, with only a few brachiopods being recovered from the upper two members.

On Mynydd Cricor, the Cricor Formation is not as distinct lithologically as its equivalents on Cyrn-y-brain and at Glyn Ceiriog. It consists of impersistent bands of fine to coarse sandstone interbedded with bluish mudstones and attains a thickness of about 20 m. The beds yielded only a few unidentifiable brachiopods.

Age and correlation

To apply the fine zonation established at Cautley and Dent (Ingham 1966) is impossible at Glyn Ceiriog, where the fauna remained largely unchanged throughout Ashgill times. The overall size and diversity of the fauna gives it a definite Cautleyan aspect but, as can be seen from Table 1 where the localities are arranged in ascending order, there are subtle changes which may help to indicate which stage or stages are represented. Forms restricted to the lower part of the Dolhir Formation are also best known from the Cautleyan stage in Yorkshire e.g., *Catazyga* (zones 1–3), *Gunnarella* (zone 3), *Porambonites* (zone 3) and *Spinorthis* (zone 4). It seems therefore that the lower part of the Dolhir Formation can be taken as being high Cautleyan (zones 3–4) in age and ranging up into the Rawtheyan in the upper parts. This borne out by the close similarity between the lower Dolhir fauna and that from the Portrane Limestone (Wright, 1963, 1964, Ms) which has also been dated as high Cautleyan (Williams in Williams *et al.* 1972 : 56). Of the 52 genera found in the Dolhir Formation, 30 are found at Portrane and 11 are regarded as conspecific.

The large Ashgill fauna of the Killey Bridge Formation, Pomeroy, dated as low Cautleyan (Mitchell, 1977), has many genera in common with the Dolhir Formation but at the same time many of the characteristic forms found at Glyn Ceiriog are absent from the Irish deposits e.g., *Fardenia*, *Katastrophomena* and *Laticrura*, and it is felt that the Killey Bridge Formation with its strong Caradoc affinities is slightly older than the Dolhir Formation.

The Rawtheyan aspect of the Dolhir fauna is confirmed by comparison with the Rhiwlas Limestone of Bala, now regarded as being early Rawtheyan (zone 5) in age (Bassett in Williams *et al.* 1972 : 25). Of the 17 genera recorded from this by Bassett *et al.* (1966 : 263, 4), 12 occur at Glyn Ceiriog. This is substantiated by comparisons with other areas in Wales from which Rawtheyan faunas have been recognized, such as the Bodeidda Mudstones and Deganwy Mudstones of Conway, north Wales (Elles, 1909; Bassett in Williams *et al.* 1972 : 22) and the Slade and Redhill Mudstone Formation of Haverfordwest, south Wales (Reed, 1905; Cocks & Price, 1975). However in many cases the faunas are in need of revision as they have not been studied for some time (Fig. 3).

Ingham's detailed zonation of the Ashgill in the Cautley and Dent districts is based on trilobite assemblages, in particular the species of *Tretaspis* and their evolution. However, at Glyn Ceiriog the most common *Tretaspis* found occurred in the lower part of the Dolhir Formation and is close to *T. hadelandica brachystichus* Ingham, a form best known from zones 5 and 6 at Cautley but which has also been recorded from as low as zone 2. A *Tretaspis* of the *T. moeldenensis* group was recovered from the Tyn-y-twmpath Member, but preservation was insufficient for precise identification and dating. However, *T. moeldenensis* Cave has been positively identified from a locality within the Tyn-y-twmpath Member 11 km west of Glyn Ceiriog (Price, 1977 : 769, 772), which suggests a correlation with the Cautleyan Sholeshook Limestone of south Wales. A *Tretaspis*, regarded by Ingham (1970 : 43) to be conspecific with *T. latilimba brøggeri* Størmer, has been recorded from high up in the Dolhir Formation near Cynwyd, about 15 km west of Glyn Ceiriog, indicating a high Rawtheyan age for those beds.

The only other commonly occurring trilobite in the Dolhir Formation is *Flexicalymeme*

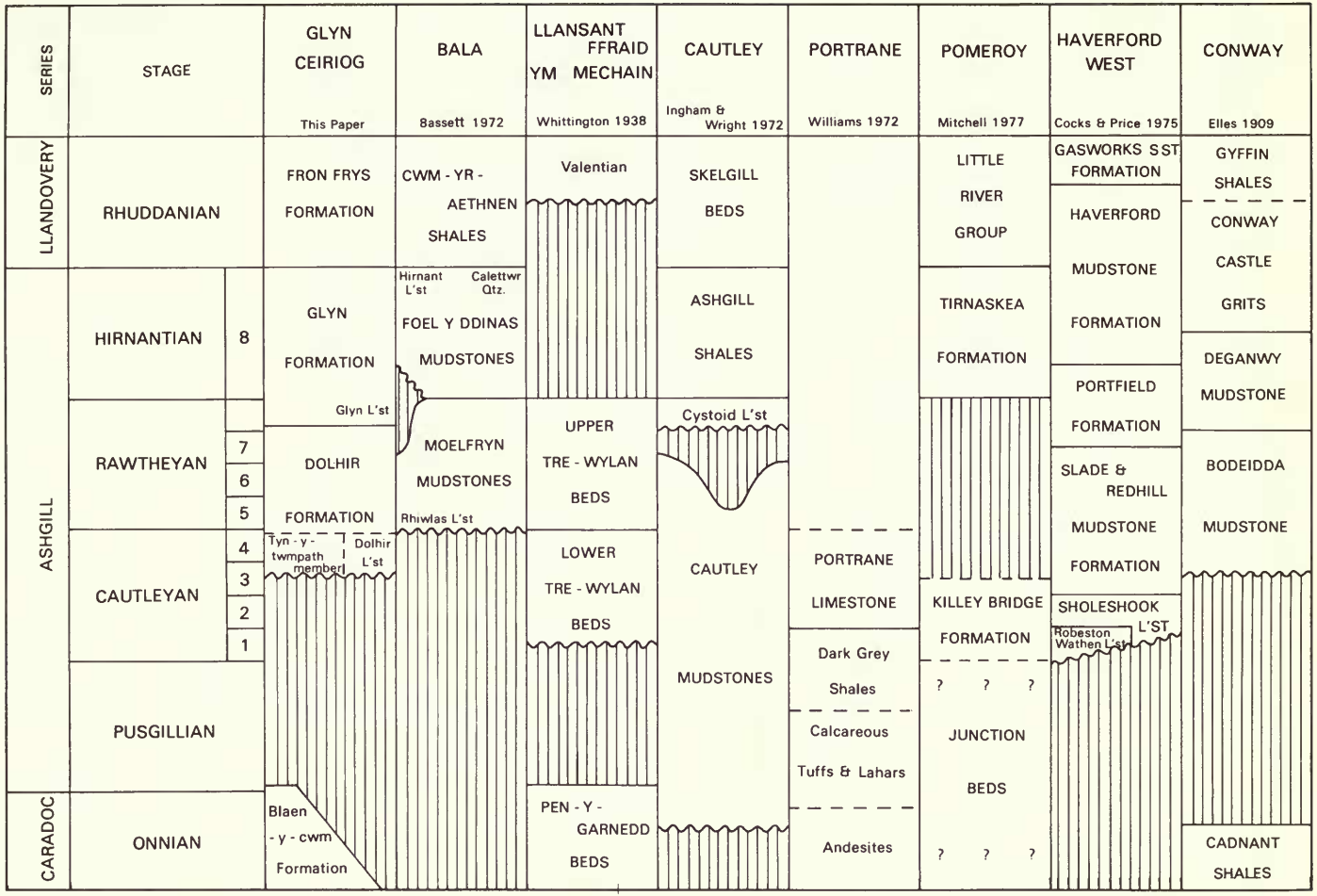


Fig. 3 Correlation of the Glyn Ceiriog succession with others in the British Isles.

quadrata (King) which may indicate a Rawtheyan age, because it occurs in the Upper Tre-wylan Beds of Llansantffraid ym Mechain (Whittington, 1938). These succeed the *P. parabola* and *D. drummuckensis* zones, both of which are considered to be Cautleyan (Ingham, 1966 : 494 and Price, 1973 : 539). The remaining trilobites from Glyn Ceiriog are not sufficiently well preserved to be of use in correlation or age determinations.

The fauna of the Glyn Formation is a continuation of that from the Dolhir Formation although it is much reduced in size. It contains elements of the widespread *Hirnantia* fauna: *Dalmanella* cf. *testudinaria* (Dalman), *Eostropheodonta hirnantensis* (M'Coy) and *Hirnantia sagittifera*? (M'Coy) and these, coupled with a stratigraphical position just below Lower Llandovery shales, might suggest a Hirnantian age for the formation: however, the diversity of the fauna and the presence of *Flexicalymene quadrata* at the base of the formation indicates a slightly older age.

The fauna of the Cyrn-y-brain Formation is typified by forms found only in the higher part of the Dolhir and Glyn Formations. If the preceding age determinations are to be accepted, then a Rawtheyan age is indicated for that part of the formation from which fossils have been collected. The presence of *Cryptothyrella crassa incipiens* (Williams), *Eostropheodonta hirnantensis* and *Plectatrypa* cf. *gaspeensis* Cooper at the top of the formation suggest a very high Rawtheyan or even Hirnantian age when compared to the Cautley and Dent succession, where such forms are known only from the Ashgill Shales (zone 8).

The three species so far recovered from the Plas Uchaf Formation, *Cliftonia* sp., *Hirnantia sagittifera*? and *Eostropheodonta hirnantensis*, are all members of the *Hirnantia* fauna and, with the formation coming between beds of Rawtheyan and Lower Llandovery ages, an Hirnantian age is concluded for the formation, which is also suggested by the restricted nature of the fauna.

Fossil localities

Tyn-y-twmpath Member: most of the fauna from this horizon was collected at locality T1 (Grid Ref: SJ 167374), in the stream bank 100 m north of Tyn-y-twmpath farmhouse, but some fossils were also recovered from T2 (Grid Ref: SJ 179369), a small exposure where the lane crosses the stream 600 m east-south-east of Tyn-y-celyn and T3 (Grid Ref: SJ 173372), a bank behind the house at Tyn-y-celyn (Fig. 4).

Dolhir Limestone Member: fossils were found 40 m below the main limestone band at locality L1 (Grid Ref: SJ 202367), in a bank marked by a line of trees 200 m south-south-east of Ddôl-hir; blocks of limestone were taken for etching from old quarries at L2 (Grid Ref: SJ 203369), by the roadside 200 m south-east of Ddôl-hir and L3 (Grid Ref: SJ 212364), south of the lane 120 m west of Cefngoed (Fig. 4).

Dolhir Formation: by far the most richly fossiliferous part of the formation lies immediately above the level of the basal members. About 1m above the limestone are localities D1 (Grid Ref: SJ 197367), among the roots of some trees 100 m south of Plas Einion and D2 (Grid Ref: SJ 199368), a small cliff 150 m east of Plas Einion; a little higher, about 16 m above the limestone is D3 (Grid Ref: SJ 198368), 50 m east of Plas Einion. 25–30 m above the limestone is D4 (Grid Ref: SJ 194367) on a ridge by the lane from Plas Einion to Aberwheel, 330 m west of Plas Einion and about 20 m higher are localities D5 (Grid Ref: SJ 193368) along the same ridge but 300 m east of Aberwheel, D6 (Grid Ref: SJ 203369) by the roadside 160 m east of Ddôl-hir and D7 (Grid Ref: SJ205368), a small exposure 300 m east of Ddôl-hir. A few specimens were obtained from D8 (Grid Ref: SJ 212365), a low cliff 160 m north-west of Cefngoed.

The fauna from the upper parts of the formation is much less diversified than at lower horizons and the number of individuals is less. There are eight main localities; D9 (Grid Ref: SJ 171375), where the lane crosses the stream 400 m north-north-west of Tyn-y-celyn, D10 (Grid Ref: SJ 155376), a low cliff by the lane 100 m north of Plas Nantyr, D11 (Grid Ref: SJ 151382), in the stream bank 800 m north of Plas Nantyr and a little higher in the sequence D12 (Grid Ref: SJ 174374), a small excavation by the side of the lane 260 m north of Tyn-y-celyn, D13 (Grid Ref: SJ 199374), a steep bank by the road 160 m west of Soar Chapel in Glyn Ceiriog village, D14 (Grid Ref: SJ 211368), a very small exposure on top of the hill 460 m south-west of Fron Frys farm.

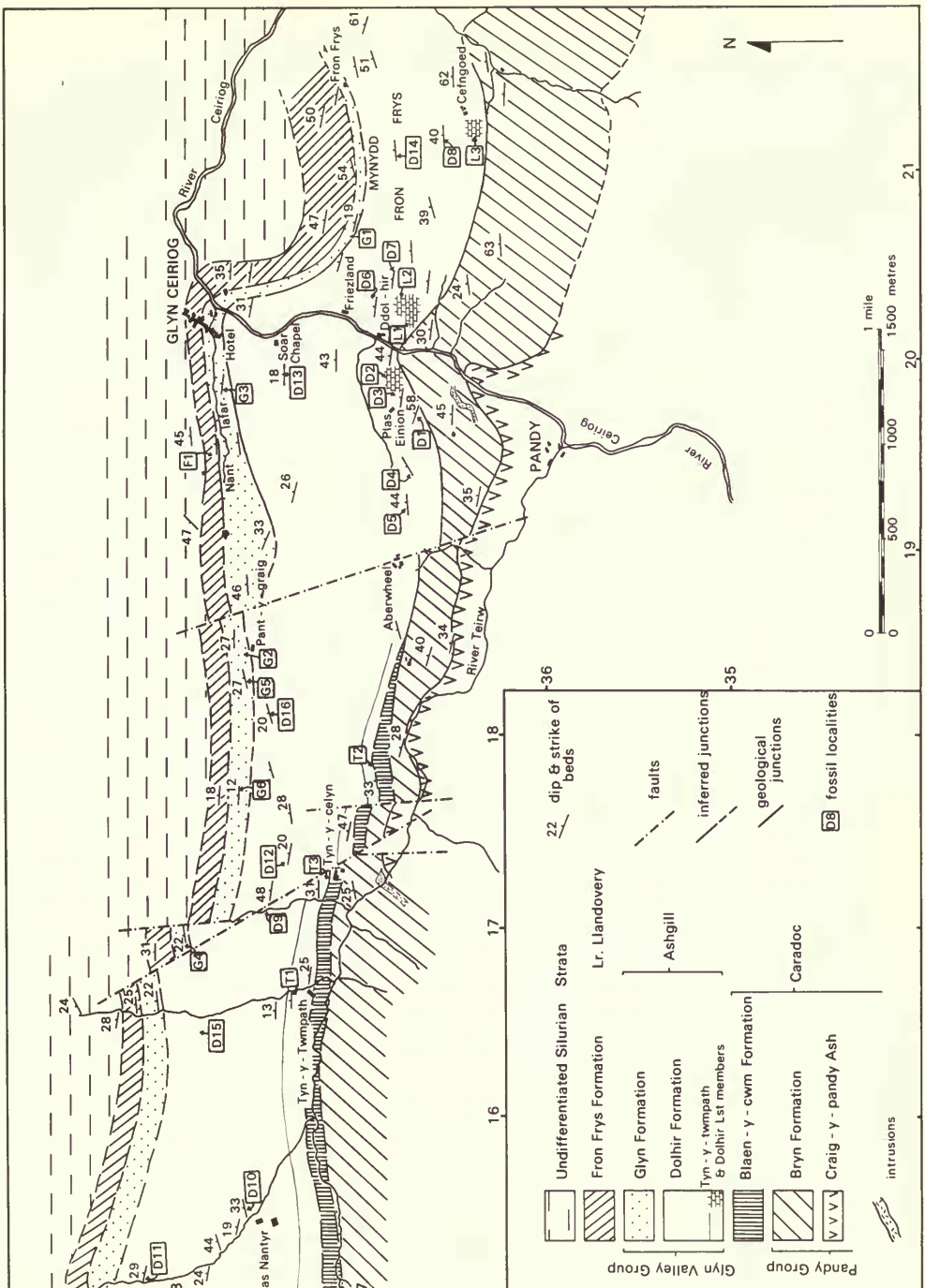


Fig. 4 Geological Map of the area around Glyn Ceiriog.

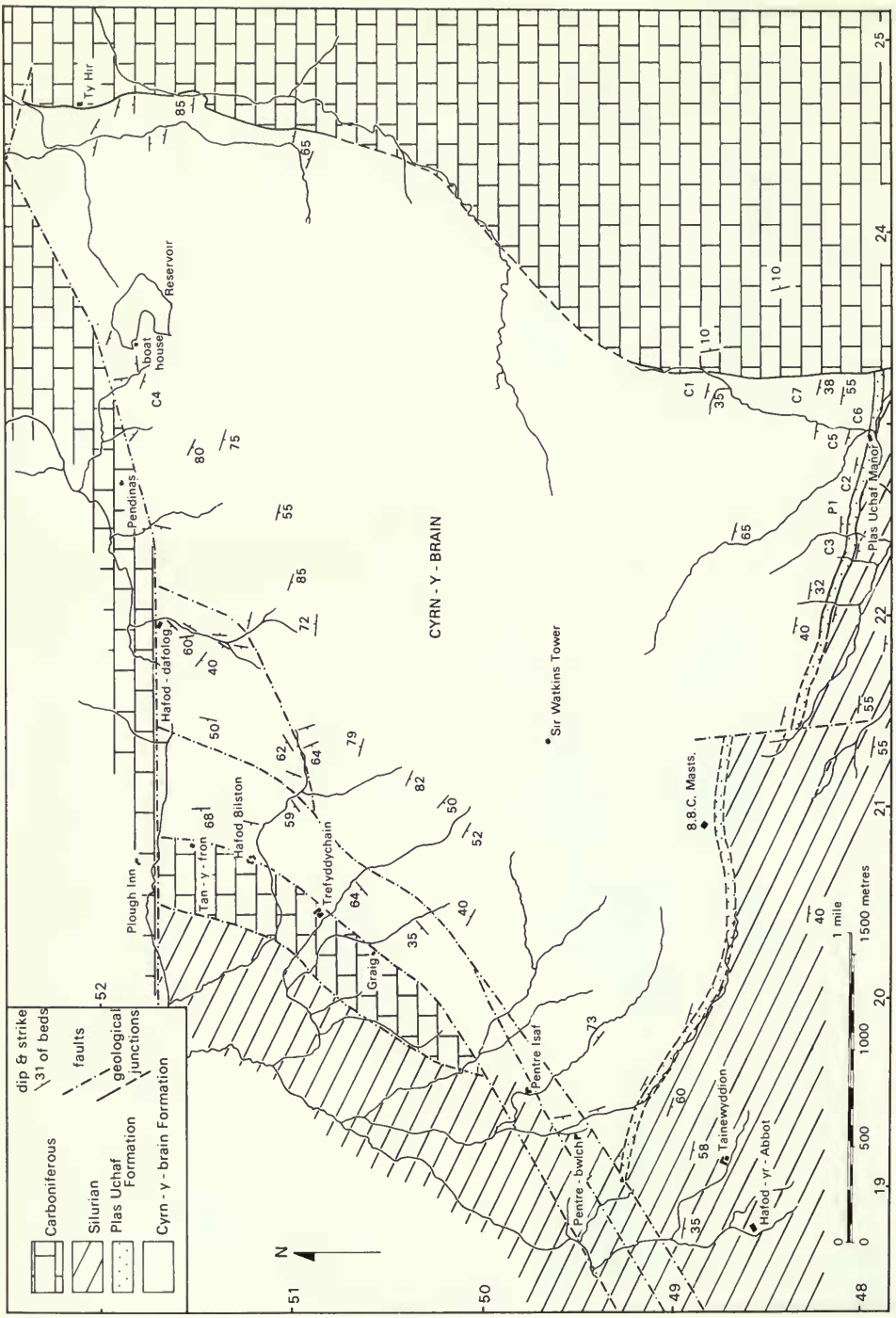


Fig. 5 Geological Map of the Cyrn-y-brain Inlier.

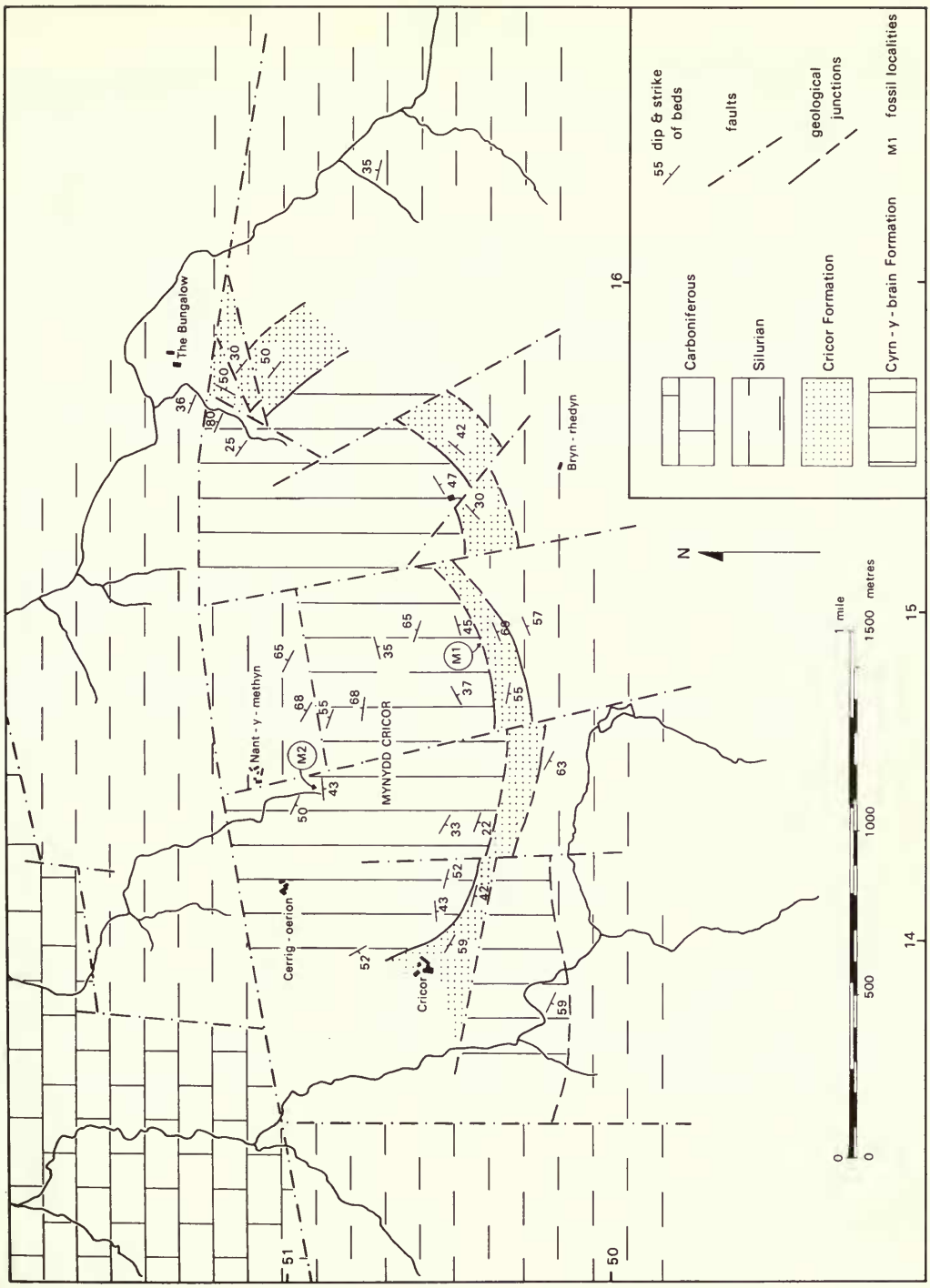


Fig. 6 Geological Map of the Mynydd Cricor Inlier.

The top 120 m of the formation are not well exposed but two localities provided a good sample of the fauna; D15 (Grid Ref: SJ 165378), an excavation by the side of the lane 600 m north of Tyn-y-twmpath and D16 (Grid Ref: SJ 181375), a small excavation by the road junction 360 m west of Pant-y-graig. (Fig. 4).

Glyn Formation: fossils were collected from the Glyn Limestone Member at locality G1 (Grid Ref: SJ 207370), an old quarry at the top of the hill, 400 m east of Friezland, and from the rest of the formation at localities G2 (Grid Ref: SJ 185376), a cliff behind the house at Pant-y-graig, G3 (Grid Ref: SJ 199377), in the southern bank of Nant Lafar by the old railway incline, 300 m west of the Glyn Valley Hotel, G4 (Grid Ref: SJ 169379), 750 m north-north-east of Tyn-y-twmpath, G5 (Grid Ref: SJ 184376), 150m west-north-west of Panty-y-graig, and G6 (Grid Ref: SJ 177376), 700 m north-east of Tyn-y-celyn (Fig. 4.)

Cyrn-y-brain Formation: most of the collections were made in the uppermost part of the formation exposed on the southern slopes of Cyrn-y-brain. The principal localities are C1 (Grid Ref: SJ 233488), in the stream banks 860 m north-north-east of Plas Uchaf Manor, C2 (Grid Ref: SJ 228480), by the side of the path 160 m west of Plas Uchaf and C3 (Grid Ref: SJ 224481), where the path crosses the stream 500 m west of the Manor house. One locality in the northern part of the inlier yielded quite a good sample from a similar horizon, C4 (Grid Ref: SJ 232518), by the side of a forestry road 200 m west of the boat house by the reservoir. Smaller collections were made from C5 (Grid Ref: SJ 229481), 100 m north of Plas Uchaf Manor, C6 (Grid Ref: SJ 232482) and C7 (Grid Ref: SJ 232483), respectively 250 m and 350 m north-east of the Manor (Fig. 5.)

The small collection taken from this formation on Mynydd Cricor was recovered mostly from localities M1 (Grid Ref: SJ 149504), 1 km south-east of Cricor farm, and M2 (Grid Ref: SJ 144509), 250 m east of Cerrig-oerion (Fig. 6.)

Plas Uchaf Formation: although this formation proved to be largely unfossiliferous a few specimens were recovered from its upper members around locality P1 (Grid Ref: SJ 225480), 400 m west of Plas Uchaf Manor (Fig. 5.)

Fron Frys Formation: a few specimens of *Plectatrypa* cf. *gaspeensis* Cooper, of Lower Llandovery age, were taken from this formation and included in the description with those recovered from the Cyrn-y-brain Formation. The locality, F1 (Grid Ref: SJ 194378), in the bank by the side of the road, 600 m west of the Glyn Valley Hotel is situated about 20 m above the base of the formation (Fig. 4.)

Systematic Palaeontology

The application of quantitative methods to the faunas from the Glyn Ceiriog district can raise considerable practical difficulties due to the distortion suffered by many of the specimens. This is caused both by post-depositional compaction and by cleavage associated with folding, but is not uniform throughout the different horizons. Those specimens recovered from the more competent Glyn and Cyrn-y-brain Formations have largely escaped distortion and for the purposes of statistical analysis, measurements of size and growth ratios have been taken only on those specimens which show the minimum of distortion, i.e., those specimens in which lines that can be assumed to have been originally at right angles, have remained at right angles or nearly so. However, assessment of those characters that remain more or less unchanged even after shape has been altered can still be made on most specimens, e.g., counts of ribs at a particular growth stage.

The measurements taken on morphological features of the specimens, preserved mostly as internal and external moulds, are the same as those outlined by Mitchell (1977 : 18–19) and the treatment of the data thus obtained was by the standard approach to biometrics of Kermack and Haldane (1950) adapted for use in comparisons of data derived from brachiopods by Williams (1962 : 69–79; 1963 : 333; 1974 : 23–25). All measurements are in millimetres.

Class **INARTICULATA** Huxley, 1869
Order **LINGULIDA** Waagen, 1885
Superfamily **LINGULACEA** Menke, 1828
Family **OBOLIDAE** King, 1846
Subfamily **LINGULELLINAE** Schuchert, 1893

LINGULELLA Salter, 1866

Lingulella sp. A.
Figs 11–15

?1908 *Lingula brevis* Portlock; Groom & Lake: 572.
1922 *Lingula* sp.; Wills & Smith: 191.

MATERIAL AND HORIZON. 2 pairs of conjoined valves, 4 pedicle and 1 brachial valves from the lower part of the Dolhir Formation, 1 m–50 m above the Dolhir Limestone, and 1 pedicle valve from the middle part of the formation.

DESCRIPTION. Biconvex, elongately oval shells, dark brown to black in colour; maximum width equal to less than one-half of valve length. Pedicle valve gently convex in both profiles with gently curved sides and pointed umbo. Brachial valve slightly shorter with rounded umbo. Ornament of fine concentric growth lines; two specimens show fine reticulate pattern reminiscent of *Glossella*. Inner shell layers show very fine radial striation. Internal structures not preserved except for vague trace of median septum posteriorly in one brachial valve.

DIMENSIONS

	length	width
Pedicle valve, BB37164	c. 33	13·5
Conjoined valves, BB37165	27·5	12·8
Pedicle valve, BB37166	23·8	9·3
Conjoined valves, BB37167	c. 19	c. 9
External mould of a brachial valve, BB37168	13·6	7·2

DISCUSSION. Most of the specimens are broken or slightly crushed, but their general form resembles *L. ovata* (M'Coy, 1846), although an unequivocal specific identification is unwarranted.

? ***Lingulella*** sp. B
Figs 16, 17

MATERIAL AND HORIZON. Single pedicle valve, BB37170, from the Tyn-y-twmpath Member at the base of the Dolhir Formation. Length 19·7 mm, width 16·0 mm.

DESCRIPTION. Elongately subcircular pedicle valve, bluish-black in colour, about four-fifths as wide as long; very gently convex in both profiles. Posterior margin indented by pedicle notch one-sixth as long as valve. Ornament of concentric growth lines; inner shell layers with very fine radial striations. One small patch on exterior shows development of short spines. Internal structures not preserved.

DISCUSSION. The generic placing of this specimen is uncertain, but the fine radial striations on inner shell layers are typical of *Lingulella*, although the well developed pedicle notch is better known from the Trematidae. The small spines are similar to those on *Spinilingula* but are not arranged in regular concentric rows, so for the present the specimen is doubtfully left in *Lingulella*.

Family **CRANIOPSIDAE** Williams, 1963

PARACRANIOPS Williams, 1963

Paracraniops sp.
Figs 18–23

?1908 *Crania* (?) sp.; Groom & Lake: 572.

MATERIAL AND HORIZON. Internal and external moulds of 11 specimens from lower part of the Dolhir Formation, 1–50 m above the Dolhir Limestone.

DESCRIPTION. Sub-circular to elongately sub-oval, gently convex pedicle (?) valves over three-quarters as wide as long and one-sixth as deep as long. Apex of valves about one-eighth of valve length from posterior margin; maximum width about mid-valve. Ornament of widely spaced concentric lamellae numbering 8–10 on valves less than 6 mm long. Well developed limbus seen on several specimens.

Ventral interior with medianly situated, slightly raised, shield-shaped platform, about one-half as long as valve, bearing a pair of sub-oval adductor scars, separated at their anterior ends by very faint longitudinal depression in one specimen and a faint ridge in another. Detail obscure in rest of sample. Shell material apparently impunctate.

DIMENSIONS

	length	width
Internal mould of a pedicle valve, BB37172	1·9	1·2
External mould of a pedicle (?) valve, SMA 53.862	1·5	1·4
External mould of a pedicle (?) valve, BB37173	2·2	1·4
Internal mould of a pedicle valve, BB37174	2·2	1·7
External mould of a pedicle valve, BB37175	2·2	1·7
Internal mould of a pedicle valve, BB37176	2·0	1·3

DISCUSSION. The indifferent preservation of these small specimens makes it difficult to distinguish between brachial and pedicle valves, and those specimens which have been tentatively identified as pedicle valves have only been placed as such after comparisons with photographs of *Paracraniops pararia* Williams, 1962 and *P. macella* Williams, 1963. It would be imprudent to attempt a specific identification with the material available, although the specimens may be separated from *P. macella* on the basis of the terminal location of the apex in that species. Temple (1968 : 11 and 1970 : 10) described an unnamed species of *Paracraniops* which superficially resembles the Glyn Ceiriog form, as does the type species *P. pararia*.

Superfamily **TRIMERELLACEA** Davidson & King, 1872

Family **TRIMERELLIDAE** Davidson & King, 1872

EODINOBOLUS Rowell, 1963

Eodinobolus sp.

Fig. 24

?1908 *Obolella* (?) sp.; Groom & Lake: 572.
?1922 ?*Dinobolus* sp.; Wills & Smith: 191.

MATERIAL AND HORIZON. External and internal moulds of a single pair of conjoined valves, BB37178, from the Glyn Formation. Length about 10 mm, width about 9 mm.

DESCRIPTION. Dorsi-biconvex shells of sub-circular outline; both valves about nine-tenths as wide as long, brachial valve over one-sixth as deep as long. Shell surface apparently smooth in early growth stages but ornamented by fairly strong, concentric growth lines anteriorly. Internal structures not preserved.

DISCUSSION. This poorly preserved specimen cannot be compared to any of the known species of *Eodinobolus*, which are mostly from rocks of Caradoc age.

Order **ACROTRETIDA** Kuhn, 1949

Suborder **CRANIIDINA** Waagen, 1885

Superfamily **CRANIACEA** Menke, 1828

Family **CRANIIDAE** Menke, 1828

PHILHEDRA Koken, 1889

Philhedra cf. ***grayii*** (Davidson, 1866)
Figs 25–27

cf. 1866 *Crania* ? *Grayii* Davidson: 82, pl. 8, figs 22–24.
cf. 1978 *Philhedra grayii* (Davidson) Cocks: 31.

MATERIAL AND HORIZON. Two specimens from the lower part of the Dolhir Formation, 1 m–50 m above the Dolhir Limestone. Both brachial valves, one showing interior and exterior moulds BB37180 (length 2·5 mm, width 3·0 mm), the other a deformed external mould, BB37179.

DESCRIPTION. Brachial valve with sub-circular outline, slightly wider than long. Profile conical, height about seven-tenths of length; umbo about one-third of valve length from posterior margin on well preserved specimen; surface irregular; anterior slope slightly convex, posterior slopes slightly concave; valve profile becoming flattened marginally but width of flattened area varying around circumference. Pair of well defined, sub-circular muscle scars situated just in front of umbo. Punctae well seen over whole of internal surface. Ornament of fairly coarse, round-topped, slightly sinuous ribs, increasing in number by intercalation. Concentric growth-imbrications quite strongly developed in later stages and occasionally forming short, thick 'spines' at intersection with radial ornament.

DISCUSSION. The closest form to the Glyn Ceiriog specimens is that described from Keisley by Temple (1968 : 12). Both forms are characterized by distinctive fairly coarse ribbing which is most like that of the poorly known Wenlock form *Philhedra grayii* (Davidson, 1866) and the author follows Temple in ascribing the Glyn Ceiriog specimens to that species, although when more material becomes available it may be possible to separate them.

Class **ARTICULATA** Huxley, 1869
Order **ORTHIDA** Schuchert & Cooper, 1932
Suborder **ORTHIDINA** Schuchert & Cooper, 1932
Superfamily **ORTHACEA** Woodward, 1852
Family **ORTHIDAE** Woodward, 1852
Subfamily **ORTHINAE** Woodward, 1852
ORTHAMBONITES Pander, 1830

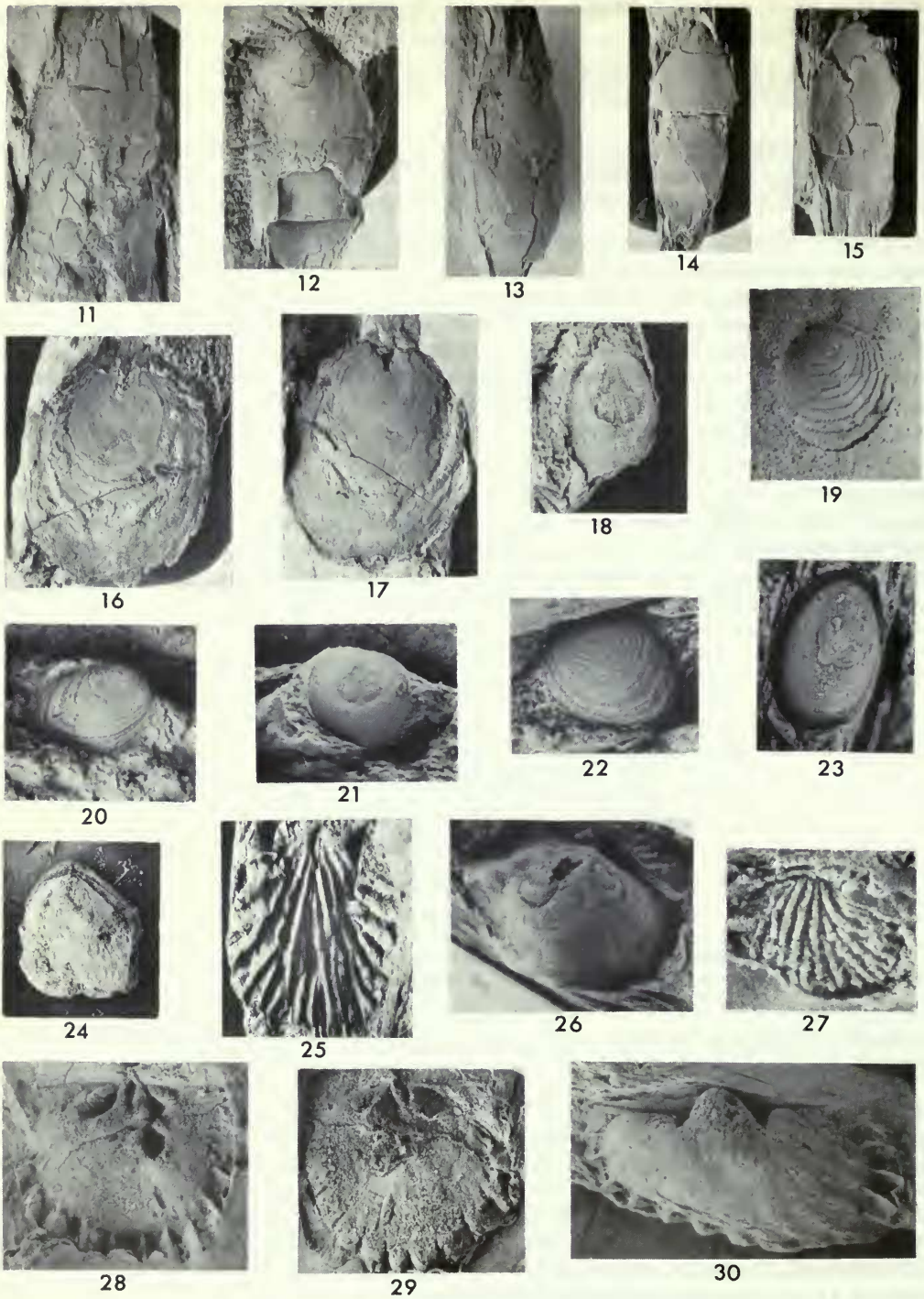
Orthambonites cf. ***humilidorsatus*** Wright, 1964
Figs 28–34, 39

1908 *Orthis calligramma* Dalman; Groom & Lake: 572, 577 (pars).
?1922 *Orthis calligramma* (?) Dalman; Wills & Smith: 187, 191 (pars).
cf. 1964 *Orthambonites humilidorsatus* Wright: 160, pl. 1, figs. 1–12.

MATERIAL AND HORIZON. Internal and external moulds of 7 pedicle and 7 brachial valves from the Dolhir Formation.

DESCRIPTION. Ventri-biconvex shells of transversely subquadrate outline with maximum width anterior to hinge-line; cardinal angles obtuse. Pedicle valve over two-thirds as long as wide and about three-tenths as deep as long; evenly convex in both lateral and anterior profiles; interarea curved, apsacline, less than one-tenth as long as valve; delthyrium open. Brachial valve three-fifths as long as wide and one-fifth as deep as long; flatly convex in lateral profile, anterior profile gently sulcate. Interarea very short, flat, anacline; notothyrium open. Ornamentation of 14–16 subangular costae on pedicle valve, 14–17 on brachial valve, and fine concentric fila yielding counts of 15 or 16 per mm, at 2 mm growth stage.

Ventral interior with short, stout teeth supported by receding dental plates; muscle field nine-tenths as long as wide and about one-third as long as valve, adductors slightly shorter than flanking diductors. *Vascula terminalia* seen in one specimen (Fig. 30). Dorsal interior with sockets bounded by short blade-like brachiophores supported only at their proximal ends by secondary shell substance. Oval-shaped cardinal process projecting from notothyrium, passing anteriorly



Figs 11–15 *Lingulella* sp. A. Dolhir Formation: Fig. 11, BB37164, Exterior of a pedicle valve, ×1·5, loc. D6; Fig. 12, BB37165, Exterior of conjoined valves, ×1·6, loc. D2; Fig. 13, BB37166, Exterior of a pedicle valve, ×1·6, loc. D2; Fig. 14, BB37167, Exterior of conjoined valves, ×1·6, loc. D6; Fig. 15, BB37168, External mould of a brachial valve, ×2·1, loc. D2.

into platform; width variable, but always becoming narrower posteriorly. Poorly defined, subquadrate adductor scars about one-half as long as valve, divided longitudinally by median ridge extending anteriorly from notothyrial platform.

DIMENSIONS

	length	width
Internal mould of a brachial valve, BB37182	6·8	7·7
Internal mould of a pedicle valve, BB37183	—	11·0
Internal mould of a brachial valve, BB37184	c. 8	c. 11
Internal and external moulds of a pedicle valve, BB37185	3·7	5·6
Internal and external moulds of a brachial valve, BB37187	5·7	10·9

DISCUSSION. The ornament of the Glyn Ceiriog *Orthambonites* (14–16 costae on 2, 1, 1 pedicle valves) bears a close resemblance to that of *O. playfairi* (Reed), *O. cessatus* Williams and *O. humilidorsatus* Wright. *O. cessatus* differs in that it lacks a dorsal sulcus, has a high ventral interarea almost one-quarter as long as valve, and it has long blade-like brachiophores. Thirty-three specimens of *O. playfairi* from Craighead, Girvan have a mean depth : length ratio of 31·8% (var. 18·0); a sample of 6 Glyn Ceiriog valves has a mean of 29·5% (var. 137·34); a 't' test showed that there was no significant difference between them. The outline of the average Welsh pedicle valve tends to be more transverse than the Scottish shells, and a test comparing the a's proved the Glyn Ceiriog species to be significantly wider ($0{\cdot}05 > P > 0{\cdot}02$). However, the deformation in some of the Welsh specimens means that no great importance can be placed on this result; similar tests on the same statistics show that there is no significant difference between the Glyn Ceiriog form and *O. humilidorsatus* from the Portrane Limestone. The cardinalia of these two forms are similar, and Wright used this character to distinguish between the Irish shells and the closely related Estonian *O. lyckholmiensis* (Wysogorski) which also has a much deeper brachial valve.

The following statistical data were obtained for the sample:
Pedicle valves Length (l) : width (w), n = 6; $\bar{l}$ (var. l) = 4·53 (2·355) mm; $\bar{w}$ (var. w) = 6·45 (5·695) mm; r = 0·821; a (var. a) = 1·555 (0·0549).

Subfamily **PRODUCTORTHINAE** Schuchert & Cooper, 1931

NICOLELLA Reed, 1917

Nicolella actoniae (J. de C. Sowerby, 1839)
Figs 35–38, 40, 41

Figs 16–17 *Lingulella* sp. B. Tyn-y-twmpath Member. BB37170, Exterior and interior of a pedicle valve, ×1·7, loc. T1.

Figs 18–23 *Paracraniops* sp. Dolhir Formation: Fig. 18, BB37172, Internal mould of a pedicle valve, ×8·4, loc. D1; Fig. 19, SM.A53.862, External mould of a (?) pedicle valve, ×11·9; Fig. 20, BB37173, Latex cast of the exterior of a (?) Pedicle valve, ×7·3, loc. D4; Fig. 21, BB37174, Internal mould of a pedicle valve, ×5·9, loc. D1; Fig. 22, BB37175, Latex cast of the exterior of a pedicle valve, ×8·2, loc. D1; Fig. 23, BB37176, Internal mould of a pedicle valve, ×10·5, loc. D5.

Fig 24 *Eodinobolus* sp. Glyn Formation: BB37178, Internal mould of conjoined valves, dorsal view, ×2, loc. G3.

Figs 25–27 *Philhedra* cf. *grayii* (Davidson). Dolhir Formation: Fig. 25, BB37179, Fragment of the external mould of a brachial valve, ×6, loc. D2; Fig. 26, BB37180, Internal mould of a brachial valve, ×10·2, loc. D6; Fig. 27, BB37180, Latex cast of a fragment of the exterior of a brachial valve, ×10·2, loc. D6.

Figs 28–30 *Orthambonites* cf. *humilidorsatus* Wright. Tyn-y-twmpath Member: Figs 28–29, BB37182, Internal mould and latex cast of a brachial valve, ×4·9, loc. T1. Dolhir Formation: Fig. 30, BB37183, Internal mould of a pedicle valve, ×4·4, loc. D5.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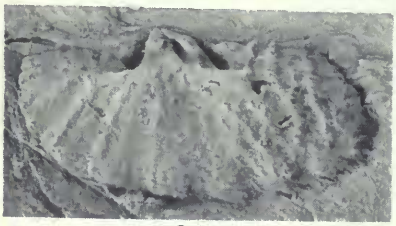
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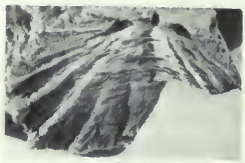
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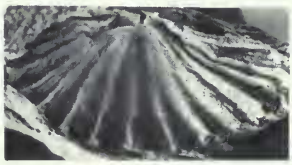
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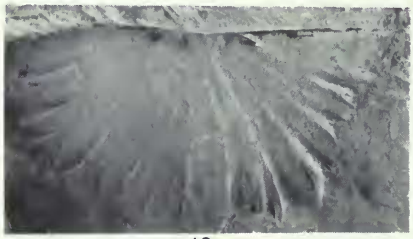
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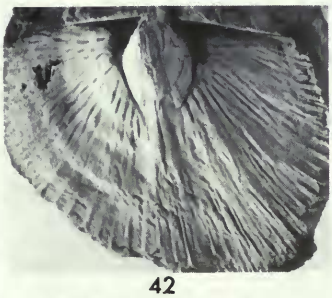
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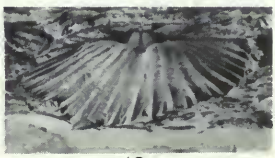
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1839 *Orthis actoniae* J. de C. Sowerby *in* Murchison: 639, pl. 20 fig. 16.
1908 *Orthis actoniae* Sowerby; Groom & Lake: 572, 577.
1917 *Orthis* (*Nicolella*) *actoniae* J. de C. Sowerby; Reed: 860 *pars*, pl. 10, figs 25, 26, non fig. 27.
1922 *Orthis actoniae* Sowerby; Wills & Smith: 191.
1963 *Nicolella actoniae* (J. de C. Sowerby); Williams: 352, pl. 1. figs 15–19.

MATERIAL AND HORIZON. Internal and external moulds of 34 pedicle, 15 brachial and one pair of conjoined valves from throughout the Dolhir Formation and Glyn Formation. Most specimens are deformed to a greater or lesser degree.

DIMENSIONS

	length	width
Internal mould of a pedicle valve, BB37189	c. 12	13·4
Internal and external moulds of a brachial valve, BB37190 . .	12·5	20·8
Internal mould of a brachial valve, BB37193	8·1	14·9
Internal mould of a pedicle valve, BB37194	10·6	14·2

DISCUSSION. In size, shape and style of ornament the Glyn Ceiriog *Nicolella* is very close to *N. actoniae* (Sowerby) and its subspecies *N. actoniae obesa* Williams, 1963, and so a full description is omitted here. Because of the deformation of the Glyn Ceiriog sample a statistical comparison with either of these two (Williams 1963) cannot be taken as reliable, but in 't' tests of valve length : maximum thickness of pedicle valves *Nicolella* from Glyn Ceiriog cannot be distinguished from either *N. actoniae* or *N. actoniae obesa*. In all the tests carried out between the Glyn Ceiriog sample and the other two forms the only significant difference established was between the Glyn Ceiriog species and *N. actoniae obesa*. In this the Glyn Ceiriog form proved to have a relatively shorter brachial valve, ($0{\cdot}05 > P > 0{\cdot}02$), and thus the shells are placed here within *Nicolella actoniae* (s.s).

The following statistical data were obtained for the Glyn Ceiriog sample:

Pedicle valves Length (l) : width (w), n = 24; $\bar{l}$(var. l) = 9·83 (14·974) mm; $\bar{w}$(var. w) = 13·39 (21·636) mm; r = 0·880; a(var. a) = 1·202 (0·0149); $\overline{\log_e l}$ (var.$\log_e$l) = 2·2129 (0·1442); $\overline{\log_e w}$(var $\log_e$w) = 2·5376 (0·1138); r_e = 0·888; α(var. α) = 0·886 (0·00761).

Length (l) : thickness (t), n = 19; $\bar{l}$(var. l) = 9·92 (19·745) mm; $\bar{t}$(var. t) = 3·25 (2·484) mm; r = 0·704; a(var. a) = 0·355 (0·00372); $\overline{\log_e l}$(var. $\log_e$l) = 2·2032 (0·1828); $\overline{\log_e t}$(var. $\log_e$t) = 1·0722 (0·2114); r_e = 0·7238; α(var. α) = 1·0756 (0·03239).

Brachial valves Length (l) : width (w), n = 14; $\bar{l}$(var. l) = 6·32 (6·910) mm; $\bar{w}$(var. w) = 11·78 (19·657) mm; r = 0·887; a(var. a) = 1·687 (0·0507); $\overline{\log_e l}$(var. $\log_e$l) = 1·7642 (0·1595); $\log_e$w (var. $\log_e$w) = 2·3999 (0·1324); r_e = 0·8941; α(var. α) = 0·9113 (0·01387).

Figs 31–34, 39 *Orthambonites* cf. *humilidorsatus* Wright. Tyn-y-twmpath Member Fig. 31, BB37184, Internal mould of a brachial valve, ×4·6, loc. T1; Fig. 32, BB37185, Internal mould of a pedicle valve, ×5, loc. T1; Fig. 33, BB37186, Latex cast of the exterior of a pedicle valve, ×5, loc. T1; Fig. 34, BB37187, Internal mould of a brachial valve, ×5, loc. T1; Fig. 39, BB37188, External mould of a brachial valve, ×5, loc. T1.

Figs 35–38, 40–41 *Nicolella actoniae* (Sowerby). Dolhir Formation: Fig. 36, BB37189, Internal mould of a pedicle valve, ×2·2, loc. D5; Fig. 37, BB37193, Internal mould of a brachial valve, ×2·6, loc. D4; Fig. 38, BB37196, Internal mould of a brachial valve, ×2·5, loc. D4. Dolhir Limestone Member: Fig. 35, BB37190, External mould of a brachial valve, ×2·4, loc. L3; Fig. 40, BB37190, Internal mould of a brachial valve, ×2·4, loc. L3. Tyn-y-twmpath Member: Fig. 41, BB37194, Internal mould of a pedicle valve, ×2·5, loc. T1.

Figs 42–47 *Dolerorthis* aff. *intercostata* (Portlock). Dolhir Formation. Figs 42, 45, BB37203, Internal mould and latex cast of a pedicle valve, ×1·4, loc. D4; Figs 43, 44, BB37197, Internal mould and latex cast of a brachial valve, ×2·4, loc. D6; Fig. 46, BB37199, Internal mould of a brachial valve, ×1·7, loc. D15; Fig. 47, BB37198, Latex cast of the exterior of a brachial valve, ×1·7, loc. D15.

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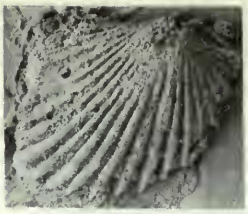

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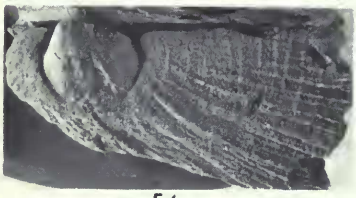

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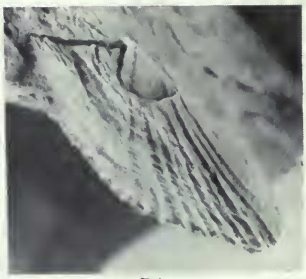

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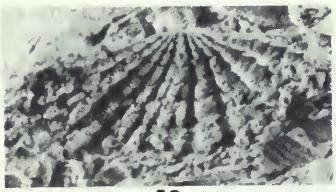

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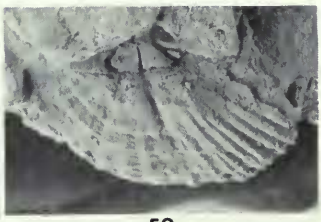

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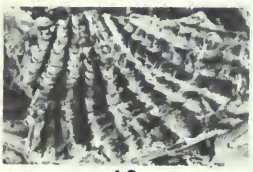

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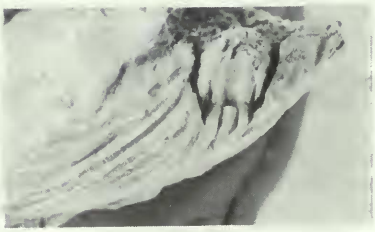

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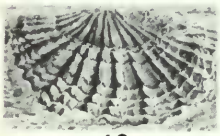

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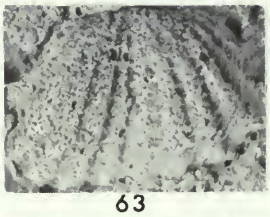

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Family **DOLERORTHIDAE** Öpik, 1934
Subfamily **DOLERORTHINAE** Öpik, 1936

DOLERORTHIS Schuchert & Cooper, 1931

Dolerorthis aff. ***intercostata*** (Portlock, 1843)
Figs 42–49, 53, 54

aff. 1843 *Orthis intercostata* Portlock: 454, pl. 37, fig. 3.
?1908 *Orthis flabellulum* Sowerby; Groom & Lake: 573 (pars).
aff. 1977 *Dolerorthis intercostata* (Portlock); Mitchell: 32, pl. 3, figs 24–27.

MATERIAL AND HORIZON. Specimens distributed throughout the Dolhir Formation with a single specimen from the Mynydd Cricor inlier, a total of 13 pedicle and 7 brachial valves, with additional fragmental material.

DESCRIPTION. Biconvex shells of transversely subquadrate outline, with maximum width at hingeline or just anterior to it, cardinal angles rectangular to obtuse. Pedicle valve almost three-quarters as long as wide, and depth ranging from one-sixth to one-third of valve length, some large valves being resupinate; lateral profile with greatest depth and convexity near umbo, becoming less convex or even concave anteriorly. Anterior profile gently convex. Interarea curved, catacline to apsacline, less than one-fifth as long as valve; delthyrium quite narrow, open. Brachial valve almost four-fifths as long as wide and one-fifth as deep as long; lateral profile evenly convex; anterior profile convex but with faint median sulcus in 6 out of 12 specimens. Interarea flat, anacline to orthocline, about one-seventh as long as valve; notothyrium open. Ornament consisting of rounded to subangular costae and costellae with subparallel sides. Ribs with density of 3 per 2 mm at 10 mm growth stage, crossed by faint fila, with density of 5–7 per mm at 5 mm growth stage, visible more clearly in rib interspaces. 13–16 primary costae at dorsal umbo with up to 5 additional costae along posterior margin on either side. Ventral ornament with median costa developing costella on either side, ribs 2 and 3 producing single external costella; rib 4 with external costella and occasionally an internal one also; rib 5 with costella on either side; commonly rib 6 and rarely rib 7 develop single costella, either internal or external; ribs lateral to 7 normally remain simple costae. Costellae do not usually become as strong as costae but differentiation commonly lost in later growth stages of large shells.

Ventral interior with strong teeth supported by receding dental lamellae; muscle field triangular to subpentagonal, almost as long as wide and three-tenths as long as valve; adductor scars about one-third as wide as whole scar and slightly shorter than diductors. Narrowly divergent trunks of *vascula media* extending anteriorly from in front of adductor scars, with *vascula genitalia* situated posterolaterally to them, are well seen in one specimen (BB37203). Dorsal interior with simple

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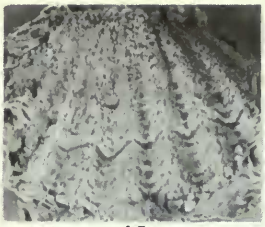
Figs 48–49, 53–54 *Dolerorthis* aff. *intercostata* (Portlock). Dolhir Formation. Fig. 53, BB37204, Internal mould of a brachial valve, ×1·4, loc. D4; Fig. 54, BB37205, Broken internal mould of a pedicle valve, ×1·7, loc. D4. Dolhir Limestone Member. Fig. 48, BB37200, Latex cast of the exterior of a pedicle valve, ×1·7, loc. L3; Fig. 49, BB37200, Internal mould of a pedicle valve, ×1·9, loc. L3.

Figs 50–52, 55 *Hesperorthis* sp. Glyn Formation. Fig. 50, BB37214, Latex cast of the exterior of a pedicle valve, ×2, loc. G2; Figs 51, 55, BB37212, Latex cast and internal mould of a pedicle valve, ×2·4, loc. G2; Fig. 52, BB37215, Internal mould of a pedicle valve, ×2·6, loc. G2.

Figs 56–62, 64 *Glyptorthis* cf. *maritima* Wright. Dolhir Formation: Fig. 56, BB37222, Internal mould of a pedicle valve, ×3·0, loc. D6; Fig. 57, BB37218, Internal mould of a brachial valve, ×3·4, loc. D6; Fig. 58, BB37225, External mould of a brachial valve, ×4·6, loc. D6; Fig. 59, BB37224, Internal mould of a brachial valve, ×3·5, loc. D2; Fig. 60, BB37218, External mould of a brachial valve, ×3·4, loc. D6; Figs. 61, 62, BB37219, External mould and latex cast of a brachial valve, ×3·5, loc. D3; Fig. 64, BB37221, Internal mould of a pedicle valve, ×3·0, loc. D6.

Fig, 63 *Ptychopleurella* sp. Glyn Formation. BB37226, Latex cast of the exterior of a brachial valve, ×5·0, loc. G1.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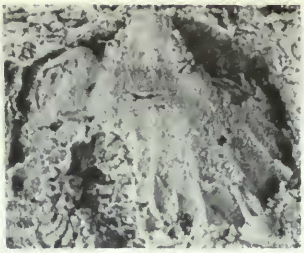
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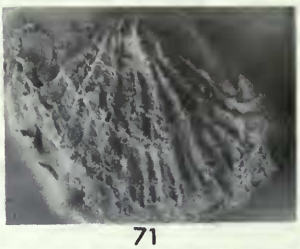
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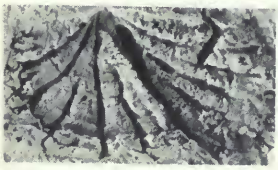
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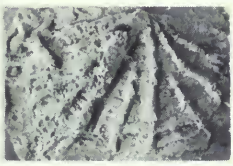
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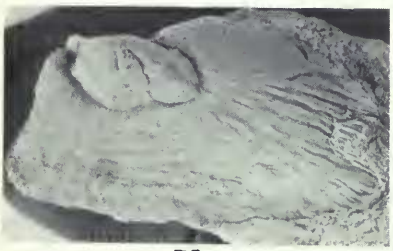
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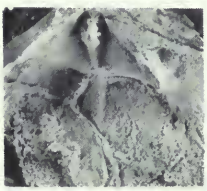
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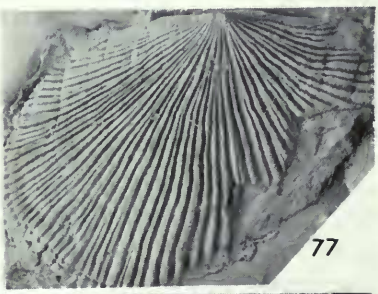
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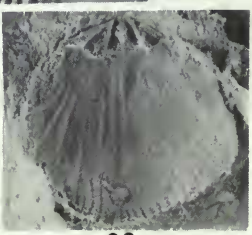
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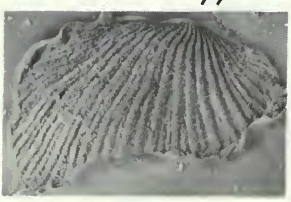
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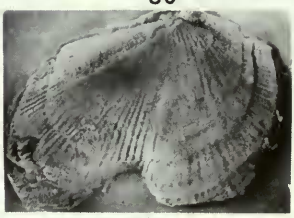
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cardinal process on thickened notothyrial platform, anterior to which is short, low, median ridge extending for three-tenths of valve length. Unsupported brachiophores short, blade-like, may be grooved along inner side. One specimen, BB37204, bears impressions of *vascula genitalia* and *vascula media* in the apocopate condition.

DIMENSIONS

	length	width
Internal mould of a brachial valve, BB37197	6·3	13·0
External mould of a brachial valve, BB37198	11·4	19·5
Internal mould of a brachial valve, BB37199	11·2	19·4
Internal mould of a pedicle valve, BB37200	18·0	25·8
External mould of a pedicle valve, BB37200	18·2	26·0
Internal mould of a pedicle valve, BB37203	28·9	32·1
Internal mould of a brachial valve, BB37204	32·4	31·0

DISCUSSION. Some features of this deformed *Dolerorthis* sample are well enough preserved to enable comparison to be made with some known stocks; e.g., the strong dorsal sulcus seen in *D. rankini* (Davidson) and *D. inaequicostata* Wright is lacking in the Glyn Ceiriog shells; the fact that only half of the brachial valves develop a faint median sulcus suggests similarities with *D. duftonensis* (Reed). One striking feature of these Welsh specimens is the resupinate nature of large pedicle valves and in this respect they resemble *D. intercostata* (Portlock) which is also faintly sulcate in the initial growth stages of the brachial valve.

The costae and costellae of the Glyn Ceiriog form are of almost equal strength at the margin of large shells. This condition applies equally to *D. duftonensis s.l.* but in *D. inaequicostata* the costellae are never as prominent as the primary ribs. Only one ventral exterior has the ornament well enough preserved to count the ribs, and this has 16 primaries at the umbo with 5 additional ribs arising along the posterior margin on either side. There are 21 ribs at the 3 mm growth stage, 23 at 5 mm and 39 at 10 mm. The pattern of ribbing on this shell does not differ markedly from that on any of the other forms except *D. tenuicostata* Williams which develops tertiary ribs.

D. duftonensis differs from the Glyn Ceiriog species in having a relatively shorter ventral muscle scar compared to valve length but its subspecies, *D. duftonensis prolixa* Williams is not significantly different in this respect; however, this latter is slightly more finely ribbed and more consistently develops a dorsal sulcus. The resupinate pedicle valve is considered to be an important characteristic of the Glyn Ceiriog species and for this reason it is suggested that it has strong affinities with the *D. intercostata* stock.

Figs 65–66 *Ptychopleurella* sp. Glyn Formation: Fig. 65, BB37227, Latex cast of the exterior of a pedicle valve, ×5·8, loc. G1; Fig. 66, BB37227, Internal mould of a pedicle valve, ×5·8, loc. G1.

Figs 67–73 *Spinorthis geniculata* Wright. Tyn-y-twmpath Member: Fig. 67, BB37231, Internal mould of a brachial valve, ×2·7, loc. T1; Fig. 68, BB37231, External mould of a brachial valve, ×2·7, loc. T1; Fig. 69, BB37234, Internal mould of a brachial valve, ×3·5, loc. T1; Figs. 70, 71, BB37233, External mould and latex cast of brachial valve, ×3·5, loc. T1. Dolhir Limestone Member: Figs. 72, 73, BB37230, External mould and latex cast of a brachial valve, ×3·5, loc. L3.

Figs 74–78, 81 *Plaesiomys porcata* (M'Coy). Cym-y-brain Formation. Fig. 74, BB37236, Latex cast of the interior of a brachial valve, ×4·1, loc. C3; Fig. 77, BB37241, Latex cast of the exterior of a pedicle valve, ×1·6, loc. C2; Fig. 78, BB37245, Latex cast of the exterior of a brachial valve, ×1·9, loc. C1; Fig. 81, BB37239, Internal mould of a pedicle valve, ×1·2, loc. C2. Glyn Formation: Fig. 75, BB37238, Broken internal mould of a pedicle valve, ×2·3, loc. G2; Fig. 76, BB37243, Latex cast of cardinalia, ×1·4, loc. G3.

Figs 79–80, 82–83 *Schizophorella* cf. *fallax silicis* Wright. Cyrn-y-brain Formation: Figs 79, 80 BB37249, Internal mould and latex cast of a brachial valve, ×2·7, ×2·5, loc. C2; Fig. 83, BB37247, Latex cast of the exterior of a pedicle valve, ×1·6, loc. C2. Glyn Formation: Fig. 82, BB37250,

Subfamily **HESPERORTHINAE** Schuchert & Cooper, 1931

HESPERORTHIS Schuchert & Cooper, 1931

Hesperorthis *sp.*
Figs 50–52, 55

?1908 *Orthis calligramma* Dalman; Groom & Lake: 572, 577 (pars).
?1922 *Orthis calligramma* Dalman; Wills & Smith: 187, 191 (pars).

MATERIAL AND HORIZON. Internal and external moulds of 12 pedicle valves (e.g. BB37212, l = 14·3, w = 14·2; BB37214, l = 9·4, w = 11·3; BB37215, l = 13·0, w = 14·1) and 4 brachial valves, all from the Glyn Formation.

DESCRIPTION. Plano-convex shells of transversely subquadrate outline; maximum width along hinge-line or just anterior to it; cardinal angles rectangular to slightly obtuse. Pedicle valve almost nine-tenths as long as wide and nearly one-third as deep as long; moderately convex in both lateral and anterior profiles. Interarea high, curved, apsacline, over one-fifth as long as valve; delthyrium open with apical plate well developed. Brachial valves poorly preserved but about two-thirds as long as wide with broad shallow sulcus arising at umbo; interarea short, flat, anacline; notothyrium open. Ornamentation of rounded costae, 22–24 being recorded for 4, 0, 1 pedicle valves; interspaces also rounded.

Ventral interior with teeth supported by high thin dental plates; muscle field elongate, about four-fifths as wide as long and about one-third as long as valve. Dorsal interior with simple ridge cardinal process; other features not seen.

DISCUSSION. *Hesperorthis* has been recorded from a few localities in Britain in recent years, but the genus has often been listed under *Orthis calligramma* and, until the existing lists have been re-examined, its distribution must remain uncertain. Williams (1962 : 107) described two species from the Girvan area, *H. australis exitis* and *H. craigensis*, neither of which are the same as the Welsh shells, both having finer ornamentation with 30–33 and 26–30 costae respectively. An unnamed species of *Hesperorthis* from Pomeroy (Mitchell, 1977 : 34) is said to resemble *H. australis exitis* and is therefore unlike the Glyn Ceiriog form. However, *Hesperorthis* sp. from the Portrane Limestone (Wright, 1964 : 711) is very like the present specimens, especially one pedicle valve with 22 ribs (Wright 1964 : Pl. 2 figs 8, 9, 14).

Subfamily **GLYPTORTHINAE** Schuchert & Cooper, 1932

GLYPTORTHIS Foerste, 1914

Glyptorthis cf. ***maritima*** Wright, 1964
Figs 56–62, 64

1908 *Orthis crispa* M'Coy: Groom & Lake: 573, 577.
1922 *Orthis crispa* M'Coy: Wills & Smith: 191.
cf. 1964 *Glyptorthis maritima* Wright: 172, pl. 1, figs. 21–29.

MATERIAL AND HORIZON. Internal and external moulds of 20 brachial and 15 pedicle valves from the lower part of the Dolhir Formation and the Glyn Formation. A lot of the material is fragmentary and a certain amount of distortion is observed.

DESCRIPTION. Ventri-biconvex shells of transversely subquadrate outline. Pedicle valve about four-fifths as long as wide and one-quarter as deep as long; maximum width anterior to hinge-line; cardinal angles obtuse. Lateral and anterior profiles evenly convex. Interarea gently curved, apsacline; delthyrium open. Young forms with faint, narrow fold which disappears in later growth stages. Brachial valve with sulcus originating at umbo, but becoming shallower and flattening out anteriorly. Interarea short, flat, anacline; notothyrium open. Radial ornament of costae and costellae with total number of ribs at 3 mm ranging from 12–18 (mode 14), and at 5 mm, 16–24 (mode 18). Concentric lamellae well developed, varying from 1–4, but most commonly 2, per mm at 5 mm growth stage.

Ventral interior with subquadrate muscle scar about nine-tenths as wide as long, and one-third as long as valve and situated on low platform; slightly elevated median adductor scars about one-half as wide as complete scar. Teeth strong; dental plates bound muscle platform. *Vascula media* emanating from front of muscle scar. Dorsal interior with blade-like brachiophores bounding notothyrium; low median ridge extending from notothyrial platform to divide poorly defined adductor scars. Cardinal process a strong simple ridge.

DIMENSIONS

	length	width
Internal and external moulds of a brachial valve, BB37218 . .	7·9	—
External mould of a brachial valve, BB37219	4·9	9·0
Internal mould of a pedicle valve, BB37222	c. 11	—
Internal mould of a brachial valve, BB37224	6·1	9·7
External mould of a brachial valve, BB37225	2·9	5·9

DISCUSSION. The distorted and fragmentary specimens from Glyn Ceiriog do not lend themselves readily to a statistical analysis. However, enough information can be gleaned about the ribbing pattern and size of the ventral muscle field to allow comparisons with species bearing a close likeness to the Welsh form. In comparisons with shells of a similar age the closest morphological similarity with the Glyn Ceiriog species lies in the Portrane Limestone *G. maritima*. The contemporary American species *G. pulchra* (Wang, 1949), *G. insculpta* (Hall, 1847). *G. crispata* (Emmons, 1842) and *G. bellarugosa* (Conrad, 1843) all have finer ornament, and all but *G. crispata* have persistent dorsal sulci. Of the British species *G. speciosa* (Reed, 1944), from the Drummuck Group, differs in having a slightly finer ornament, maximum width along the hinge-line and a pronounced ventral fold. *G. balcletchiensis* (Davidson, 1883) has a similar outline to the Glyn Ceiriog form, but has a longer ventral muscle field, finer imbricate ornament and a more persistent dorsal sulcus.

G. maritima has an outline and ornament similar to the Glyn Ceiriog shells and no significant difference was found between the two in the length of the ventral muscle field relative to the length of the valve. However, whilst both forms possess an impersistent dorsal sulcus, it was replaced by a fold in some of the Portrane specimens, a feature not seen in the Glyn Ceiriog sample; also a significant difference was revealed between the two in a comparison of the length of the ventral muscle field relative to its width, the Glyn Ceiriog form was found to have a significantly wider muscle scar ($0{\cdot}002 > P > 0{\cdot}001$).

Therefore it is felt that although the Glyn Ceiriog *Glyptorthis* is close to *G. maritima*, it may not be exactly conspecific with it, and the material available was judged to be too poor for further assessments of the specific character of the shells to be made.

The following statistical data were obtained for the Glyn Ceiriog sample:

(*a*) Length (l) : thickness (d) of pedicle valves; n = 9; $\bar{l}$(var. l) = 6·08 (7·892) mm; $\bar{d}$(var. d) = 1·80 (0·568) mm; r = 0·9185; a(var. a) = (0·0016).

(*b*) Length of pedicle valve (l) : width of pedicle valve (w); n = 11 : $\bar{l}$(var. l) = 7·55 (17·661) mm; $\bar{w}$(var. w) = 9·24 (15·515) mm; r = 0·8800; a(var. a) = 0·937 (0·022); $\overline{\log_e l}$(var. $\log_e$l) = 1·8859 (0·02701); $\overline{\log_e w}$(var. $\log_e$w) = 2·1398 (0·1670); r_e = 0·8937; α(var. α) = 0·7862 (0·01382).

(*c*) Length (l) : width (w) of ventral muscle scar; n = 11; $\bar{l}$(var. l) = 2·56 (1·713) mm; $\bar{w}$(var. w) = 2·49 (1·495) mm; r = 0·9735; a(var. a) = 0·9343 (0·00507).

(*d*) Length of ventral muscle scar (m) : valve length (l); n = 9; $\bar{m}$(var. m) = 2·29 (1·671) mm; l(var. l) = 8·29 (18·534) mm; r = 0·8775; a(var. a) = 3·33.

(*e*) Ratio of width of adductor scar : width of complete scar. Seven valves show a mean of 52·2% (var. 105·85) for this statistic.

(*f*) Length (l) : width (w) of brachial valves; n = 14; $\bar{l}$(var. l) = 6·39 (21·26) mm; $\bar{w}$(var. w) = 9·64 (22·27) mm; r = 0·881; a(var. a) = 1·023 (0·01953).


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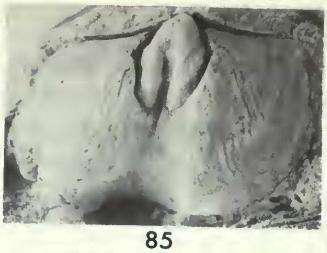
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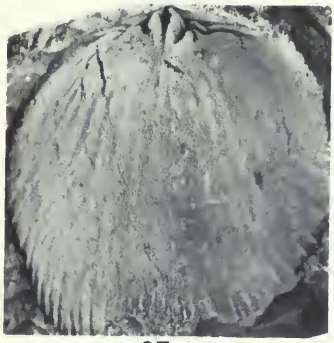
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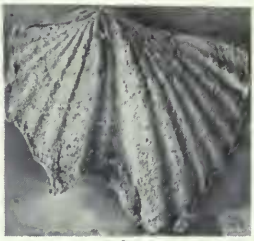
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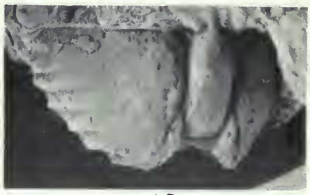
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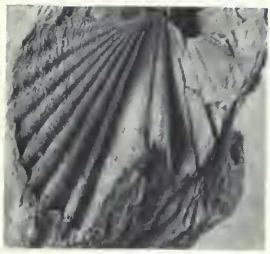
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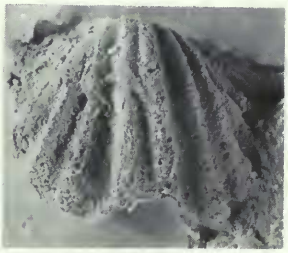
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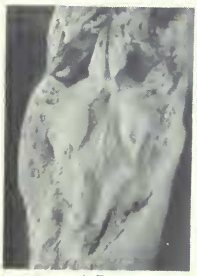
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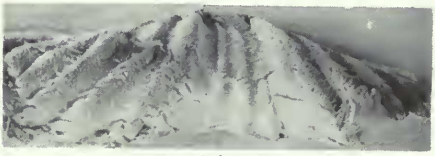
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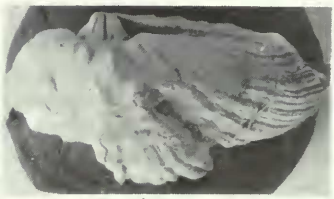
98

PTYCHOPLEURELLA Schuchert & Cooper, 1931

Ptychopleurella sp.
Figs 63, 65, 66

1927 *Orthis* aff. *bouchardi* Davidson: Wedd, Smith & Wills: 38, 39.

MATERIAL AND HORIZON. Internal and external moulds of a pedicle valve, BB 37227 (length 5·3, width 5·7), and an external mould of a brachial valve, BB 37226 (length c. 4, width 6·2), from the Glyn Limestone Member at the base of the Glyn Formation.

DESCRIPTION. Small subquadrate, biconvex shells with maximum width about mid-valve; cardinal angles obtuse. Pedicle valve about nine-tenths as long as wide and one-quarter as deep as long; both profiles evenly convex. Interarea flat, apsacline, about one-fifth as long as valve; delthyrium open. Brachial valve two-thirds as long as wide and one-third as deep as long. Lateral profile convex; anterior profile convex except for well developed median sulcus which expands anteriorly. Ornamentation of concentric lamellae with density of 3–5 per mm at 3 mm growth stage; occasional strong growth stage present. Radial ornament of simple costae with 11 on pedicle valve—a median rib with 5 on either flank; and 13 on brachial valve, 2 in sulcus with 5 or 6 on flanks.

Ventral interior with teeth supported by very short, receding dental plates; muscle field confined to umbonal cavity and of sub-triangular outline, over three-quarters as long as wide and over one-quarter as long as valve. Dorsal interior unknown.

DISCUSSION. Specific identification of *Ptychopleurella* depends largely on the nature of the ornament, and the present sample is too small to assess variation within the population. However, a close resemblance to *P. twenhofeli* Wright, 1964, from the Portrane Limestone, is seen both in the general form of the shells and in the number of ribs present.

SPINORTHIS Wright, 1964

Spinorthis geniculata Wright, 1964
Figs 67–73

1964 *Spinorthis geniculata* Wright: 185, pl. 5, figs. 1–8, 10–12.

MATERIAL AND HORIZON. Five brachial valves preserved as internal and external moulds (e.g. BB37230, l = 6·0, w = 9·6; BB37231, l = 9·6, w = 11·7; BB37233, l = 8·6, w = 11·1) from the lowest part of the Dolhir Formation. (Tyn-y-twmpath Member and its lateral equivalent at the base of the Dolhir Limestone).

DESCRIPTION. Subquadrate valves almost three-quarters as long as wide; lateral profile convex umbonally, becoming flatter anteriorly before being sharply deflected dorsally at between 7–8 mm

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Figs 84–87 *Schizophorella* cf. *fallax silicis* Wright. Cyrn-y-brain Formation: Figs. 84, 85, BB37247, Internal mould and latex cast of a pedicle valve, ×1·6, ×2·3, loc. C2. Glyn Formation: Fig. 86, BB37246, Broken internal mould of a pedicle valve, ×3·1, loc. G3; Fig. 87, BB37251, Internal mould of a brachial valve, ×2·2, loc. G3.

Figs 88–97 *Platystrophia anomala* sp. nov. Dolhir Formation: Figs 88, 89, Holotype, BB37256, External mould and latex cast of a pedicle valve, ×3, ×2·5, loc. D4; Fig. 90, BB37258, External mould of a pedicle valve, ×2·5, loc. D5; Fig. 91, BB37267, Internal mould of a brachial valve, ×3·5, loc. D4; Fig. 92, BB37262, Internal mould of a pedicle valve, ×3·8, loc. D5; Fig. 93, BB37263, Internal mould of a pedicle valve, ×3, loc. D6; Fig. 94, BB37261, Latex cast of the exterior of a brachial valve, ×3·7, loc. D6; Fig. 95, BB37265, Internal mould of a brachial valve, ×3·5, loc. D6; Fig. 96, BB37259, Latex cast of the exterior of a pedicle valve, ×2·8, loc. D7; Fig. 97, BB37257, Fragment of the external mould of a brachial valve, ×3·5, loc. D5.

Figs 98–99 *Platystrophia lutkevichi costellata* subsp. nov. Cyrn-y-brain Formation: Fig. 98, BB37269), Internal mould of a brachial valve, Holotype, ×1·2, loc. C2; Fig. 99, BB37272, Internal mould of a pedicle valve, ×2·4, loc. C2.

from umbo; anterior profile, before deflection, very gently convex except for broad, shallow median sulcus bounded on either side by a strong costa. Interarea extremely short, almost linear except for median portion. Radial ornament of sharply crested costae and costellae giving a basic pattern of 3 strong costae on either flank with costellae commonly arising by intercalation; a later median costa arises in the sulcus at between 2 mm and 3 mm from umbo. Concentric ornament of strong frills spaced at about 1 mm intervals with fine growth lines occasionally observed. At intersection of radial and concentric ornaments, hollow spines project at a steep angle from the surface of the valve, although they are not well preserved.

Interior of brachial valve with simple cardinal process situated on notothyrial platform from which a broad rounded ridge extends anteriorly to divide adductor muscle field, details of which are obscure. Thin, blade-like brachiophores diverge at 115°–120°; sockets shallow. Pedicle valve interior unknown.

Discussion. These few specimens can be closely compared with *S. geniculata* Wright, 1964. Although the deflection cannot be seen well in the Glyn Ceiriog shells, it occurs at about the same growth stage, i.e. at 7·4 mm from the umbo as compared to 7·15 mm in the Portrane form.

The mean width of the sulcus 3 mm from the umbo is 1·6 mm in 4 Glyn Ceiriog valves compared with 1·5 mm for 21 valves of *S. geniculata* from Portrane and the development of ribs in the sulcus is similar. The basic ribbing pattern is also the same for both samples; at the 5 mm growth stage the Glyn Ceiriog forms give total rib counts of 11, 12, 13, 13, 13 on 5 valves while the Portrane species has 11, 12, 13, 15, 15 ribs on 5 valves, which on a Rank Sum Test show no significant difference. On the basis of the brachial valves therefore, the Glyn Ceiriog shells may be regarded as being conspecific with the Irish specimens.

Family **PLAESIOMYIDAE** Schuchert, 1913
Subfamily **PLAESIOMYINAE** Schuchert, 1913
PLAESIOMYS Hall & Clarke, 1892
Plaesiomys porcata (M'Coy 1846)
Figs 74–78, 81

1846 *Orthis porcata* M'Coy: 32, pl. 3, fig. 14.
1908 *Orthis porcata* M'Coy: Groom & Lake: 573, 577.
cf. 1922 *Orthis* (*Plaesiomys*) *porcata* M'Coy: Wills & Smith: 191.

Material and horizon. Internal and external moulds of 3 pairs of conjoined valves, 5 brachial valves and 10 pedicle valves from throughout the Dolhir Formation and Glyn Formation.

Description. Dorsi-biconvex to convexo-concave shells of transversely sub-elliptical outline, maximum width anterior to hinge-line. Pedicle valve almost three-quarters as long as wide and one-sixth as deep as long, maximum depth close to umbo. Cardinal angles obtuse. Interarea about one-fifth as long as wide and about one-fifth as long as valve; flat, varying from apsacline to catacline; delthyrium open. Lateral profile varying from very gently convex to slightly concave; anterior profile slightly convex to flat. Brachial valve evenly convex in both profiles with faint sulcus modifying anterior profile in 3 out of 8 specimens. Depth over one-quarter of valve length on average but ranging from one-sixth to one-half. Interarea very short, less than one-tenth of valve length, curved orthocline to slightly apsacline. Ornament of subangular to rounded costae and costellae with about 17 primary costae on pedicle valve increasing to 28–34 ribs by 10 mm stage.

Ventral interior with teeth supported by receding dental plates which continue anteriorly to form low ridge bounding sub-pentagonal muscle field. This is almost as long as wide and extends for just over one-third of valve length. Pedicle callist small, medianly situated adductor scars small, elongately oval and almost enclosed by triangular diductor lobes; lateral diductor lobes well developed.

Dorsal interior with simple brachiophores diverging at about 90° and extending for about one-sixth of valve length, and supported only by secondary shell substance. Notothyrial platform

moderately thick with high cardinal process differentiated into narrow shaft and grooved myophore. Low ridge extends anteriorly from platform to bisect slightly impressed adductor field which is just over two-thirds as long as wide. Suboval posterior scars larger than subquadrate anterior pair.

DIMENSIONS

	length	width
Internal mould of a brachial valve, BB37236	5·9	11·0
Internal mould of a pedicle valve, BB37238	c. 17	c. 22
Internal mould of a pedicle valve, BB37239	20·2	25·5
External mould of a pedicle valve, BB37241	27·0	c. 33
Internal mould of a brachial valve, BB37243	26·7	33·0
External mould of a brachial valve, BB37245	16·0	28·0

DISCUSSION. *Plaesiomys porcata* (M'Coy, 1846) is a widespread form in British Ashgill rocks, and the specimens described here are very close to topotype specimens except for the occasional development of a faint sulcus in the brachial valve. An important feature of the Plaesiomyidae is the ventral muscle field and in this respect there was no significant difference between the Welsh stock and topotype *P. porcata* from the Portrane Limestone (Wright 1964 : 188) on comparison of length : width ratios of the muscle scar. The two forms are also similar in the length : width ratios of the pedicle valves, although the Glyn Ceiriog sample is relatively shallower with a mean depth : length ratio of 17·6% (var. 24·19) for 11 valves, while 4 Portrane valves show the ratios 22, 23, 24 and 27%, but the difference is not significant. The broken nature of the material makes reliable data on the ribbing of the Glyn Ceiriog specimens difficult to obtain, but a density of 2–4 ribs per 2 mm was observed on 1, 3, 1 pedicle valves measured medianly 5 mm from the umbo. Three brachial valves give total counts of 28, 34, 37 ribs at the 7·5 mm growth stage. Corresponding measurements on *P. porcata* show another close similarity between the two forms.

Family **PLECTORTHIDAE** Schuchert & Le Vene, 1929

Subfamily **PLECTORTHINAE** Schuchert & Le Vene, 1929

SCHIZOPHORELLA Reed, 1917

Schizophorella cf. ***fallax*** (Salter, 1846) ***silicis*** Wright, 1964

Figs 79, 80, 82–87

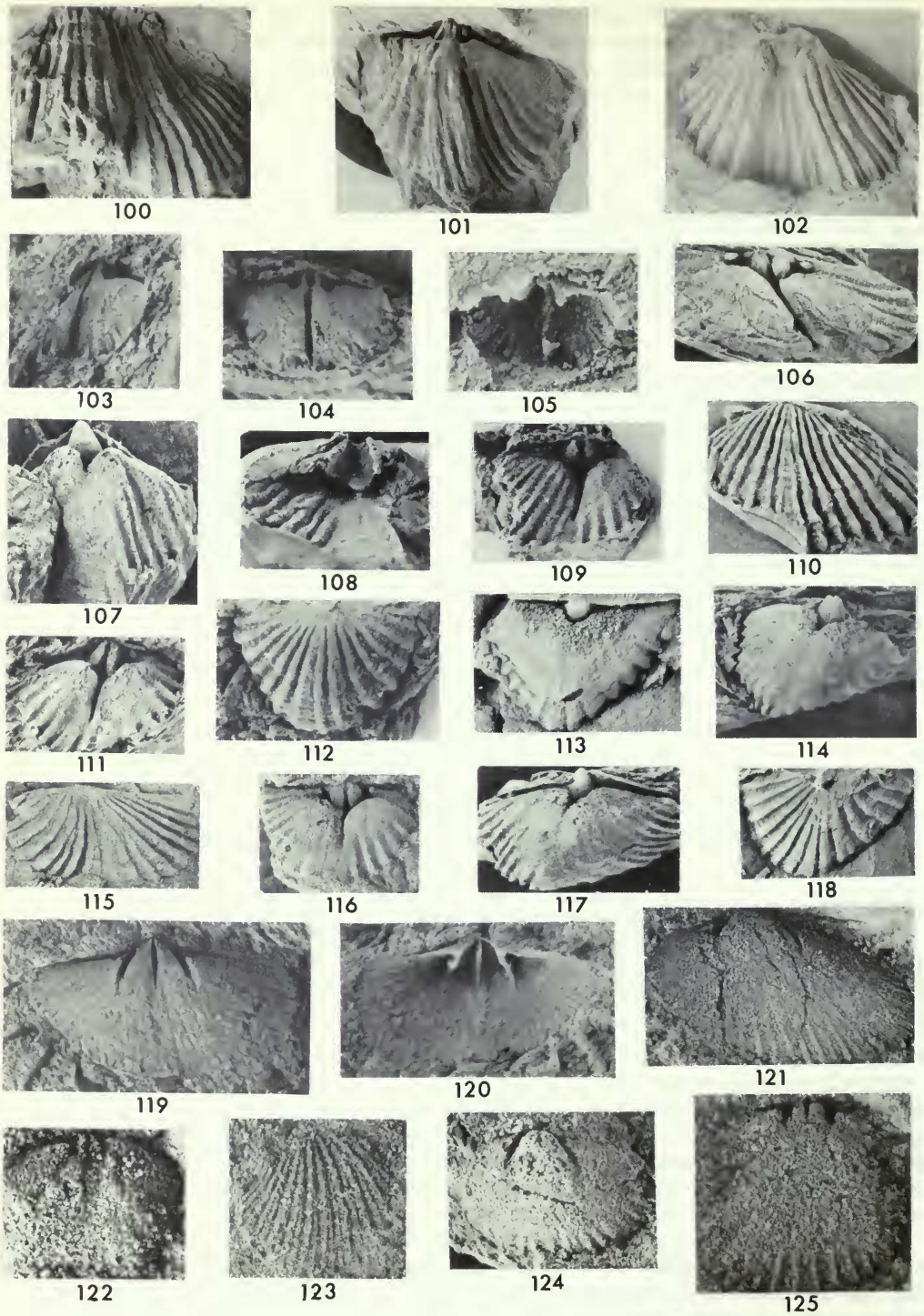
1927 *Orthis* (*Platystrophia*) *spiriferoides*, M'Coy: Wedd, Smith & Wills: 38 (pars).

cf. 1964 *Schizophorella fallax silicis* Wright: 198, pl. 5, figs 9, 13–19, 22, 23, pl. 6, fig. 1.

MATERIAL AND HORIZON. Internal and external moulds of 2 brachial and 5 pedicle valves from the Glyn Formation, and 3 brachial and 3 pedicle valves from the Cyrn-y-brain Formation.

DESCRIPTION. Biconvex shells of rounded to transversely elliptical outline; cardinal angles obtuse, rounded; hinge-line width almost three-quarters of maximum valve width. Pedicle valve over seven-tenths as long as wide and just over one-quarter as deep as long; lateral profile convex, anterior profile convex, indented medianly by gently rounded sulcus originating at about 7 mm from umbo; anteriorly sulcus may form tongue-like dorsal projection. Interarea gently curved, apsacline, about one-quarter as long as valve; delthyrium open. Brachial valve about seven-tenths as long as wide and almost two-fifths as deep as long with broad median fold originating about 7 mm from umbo.

Ventral interior with small teeth supported by strong dental plates which converge towards valve floor and whose anterior continuance delimits lateral edges of elongate, oval muscle field. This measures over one-half as wide as long and about one-half as long as valve. Median adductor scar elevated on ridge; diductor scars partially raised from valve floor on parts of dental lamellae adjacent to muscle field. Anterior edge of muscle field indented medianly where diductor lobes extend beyond adductor ridge. Low, narrow ridge extends for short way in front of muscle field. Lightly impressed mantle canals seen to cover almost entire inner surface of one large pedicle valve (BB37247) (Fig. 7).



Figs 100–102 *Platystrophia lutkevichi costellata* subsp. nov. Cyrn-y-brain Formation: Fig. 100, Holotype, BB37269, Latex cast of the exterior of a brachial valve, ×1·7, loc. C2; Fig. 101, BB37271, Internal mould of a brachial valve, ×2·1, loc. C2; Fig. 102, BB27273, Internal mould of a pedicle valve, ×2·5, loc. C3.

Dorsal interior with low notothyrial platform with cardinal process differentiated into crenulated myophore and short, thick shaft. Brachiophores widely divergent, blade-like, supported posteriorly by plates which pass into notothyrial platform. Sockets defined by fulcral plates. Poorly defined median ridge extends anteriorly from notothyrial platform for about one-third of valve length; less marked in large specimens. Indistinct, weakly impressed adductor muscle scar about one-third as long as valve.

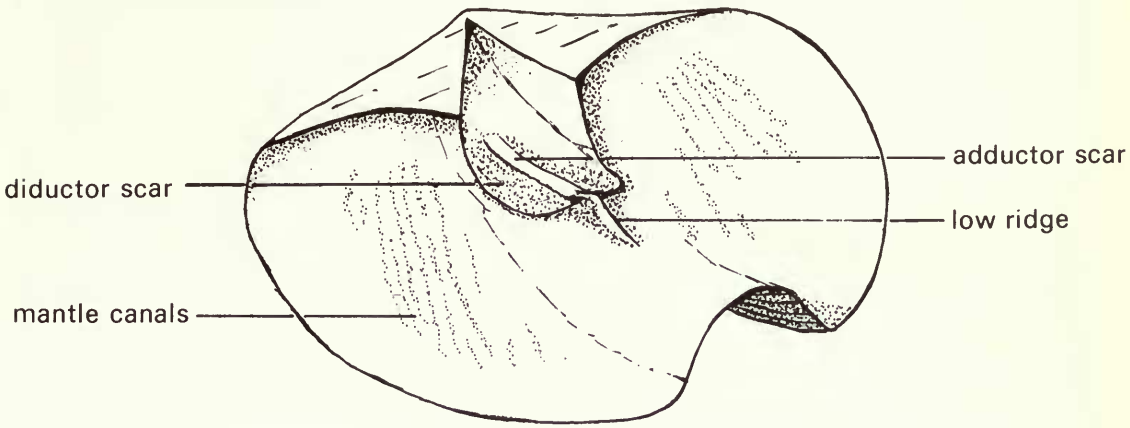


Fig. 7 Diagrammatic view of the ventral interior of *Schizophorella* cf. *fallax silicis*.

DIMENSIONS

	length	width
Internal mould of a pedicle valve, BB37246	11·4	—
Internal mould of a pedicle valve, BB37247	17·5	22·4
External mould of a pedicle valve, BB37247	17·6	22·6
Internal mould of a brachial valve, BB37249	10·8	11·3
External mould of a pedicle valve, BB37250	—	c. 14
Internal mould of a brachial valve, BB37251	20·8	20·0

DISCUSSION. The only species so far assigned to the genus are *S. fallax* (Salter, 1846), the subspecies *S. fallax silicis* Wright, 1964, and the doubtfully placed *S. kasachstanica* Rukavishnikova,

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Figs 103–105 *Cremnorthis* sp. Fig. 103, BB37275, Internal mould of a brachial valve, ×28, loc. D5; Fig. 104, 105, BB37276, Internal mould and latex cast of a brachial valve, ×18·0, loc. D5.

Figs 106–118 *Skenidioides* cf. *asteroideus* (Reed). Dolhir Formation: Fig. 116, BB37277, Internal mould of a brachial valve, ×4·8, loc. D5; Fig. 111, BB37278, Internal mould of a brachial valve, ×4·6, loc. D4; Fig. 117, BB37279, Internal mould of a pedicle valve, ×4·6, loc. D5; Fig. 110, BB37280, Latex cast of the exterior of a pedicle valve, ×4·9, loc. D5; Fig. 114, BB37284, Internal mould of a pedicle valve, ×2·8, loc. D5; Figs. 107, 108, BB37281, Internal mould and latex cast of a pedicle valve, ×4·0, loc, D5; Fig. 113, BB37282, Internal mould of a pedicle valve, ×6·2, loc. D4; Fig. 112, BB37288, Latex cast of the exterior of a pedicle valve, ×4·1, loc. D6; Fig. 109, BB37285, Internal mould of a brachial valve, ×8·2, loc. D4; Fig. 115, BB37291, Latex cast of the exterior of a brachial valve, ×3·8, loc. D15; Fig. 106, BB37290, Internal mould of a brachial valve, ×3·6, loc. D5; Fig. 118, BB37289, Latex cast of the exterior of a pedicle valve, ×3·8, loc. D4.

Figs 119–125 *Hirnantia sagittifera* ? (M'Coy). Plas Uchaf Formation: Figs 119–120, BB37292, Internal mould and latex cast of a brachial valve, ×5·9, loc. P1. Glyn Formation: Fig. 121, BB37298, Internal mould of a pedicle valve, ×3·6, loc. G3; Fig. 125, BB37295, Internal mould of a brachial valve, ×5·0, loc. G2; Fig. 122, BB37293, Internal mould of a brachial valve, ×5·3, loc. G2; Fig. 123, BB37293, Latex cast of the exterior of a brachial valve, ×5·3, loc. G2; Fig. 124, BB37297, Internal mould of a pedicle valve, ×5·0, loc. G2.

1956 from Kazakhstan, which lacks the dorsal median ridge, fulcral plates and convergent supporting plates that are characteristic of *Schizophorella fallax*. The principal difference between *S. fallax fallax* and *S. fallax silicis* is that the latter possesses a narrower more elongate ventral muscle field and a stronger dorsal median ridge. Mitchell (1977 : 46) reinvestigated the species and showed that *S. fallax silicis* has slightly coarser ribbing, but concluded from a very small sample that the difference in stature of the dorsal median ridges is of little importance.

In the small sample described here no external moulds are well enough preserved for a comparison of ornaments to be made but the ventral muscle scar on the Welsh species has similar relative dimensions to that of *S. fallax silicis*. Following Mitchell, a low taxonomic weighting is here given to the nature of the dorsal median ridge in the Glyn Ceiriog species, and much more importance to the form of the ventral muscle field; the specimens are accordingly regarded as being close to the Portrane subspecies.

Subfamily **PLATYSTROPHIINAE** Schuchert & Cooper, 1929

PLATYSTROPHIA King, 1859

Platystrophia anomala sp. nov.
Figs 88–97

1908 *Platystrophia biforata* Schlotheim: Groom & Lake: 573.

Diagnosis. A small *Platystrophia* most commonly with a single persistent median costa in the ventral sulcus, although an additional costa or two may develop in larger specimens. It differs from known species in that the second and third ribs in the sulcus do not necessarily appear even in quite large specimens.

Material and horizon. Internal and external moulds of 42 brachial and 49 pedicle valves from localities throughout the Dolhir Formation. Large specimens are mostly fragmentary but smaller ones are quite well preserved although some have been distorted by cleavage.

Description. Strongly dorsi-biconvex shells of subrectangular outline; maximum width slightly anterior to hinge-line. Ventral interarea short, flat to slightly curved, apsacline, less than one-tenth of valve length; that of brachial valve shorter, about three-fifths as long as ventral interarea, curved, anacline. Ventral sulcus deep with flat sides and floor, maximum width at anterior margin about one-third of valve width; corresponding dorsal fold high, flat-topped. Ornamentation of 5–8 strong angular costae on flanks of 9, 11, 12, 8 pedicle valves respectively at 5 mm growth stage; the number may increase to 10 in large shells by development of additional costae along posterior margin. Sulcus with single median costa umbonally; additional sulcal ribs not developed in most specimens but extra ribs may be intercalated after 4 mm growth stage. A similar development is seen on dorsal fold with up to four ribs developed by branching of two primaries. Surface of shell covered in tiny pustules.

Pedicle valve interior with moderately strong teeth and slightly ventrally convergent dental plates whose anterior ends bound elongate, suboval muscle field. This is about two-fifths as long as valve and situated on thickened platform of secondary shell. Adductor scar occupies floor of platform, which tapers posteriorly and diductor lobes are attached to inner sides of dental plates From anterior ends of dental plates pair of slightly divergent, low, sinuous ridges extend. these enclose small oval areas on either side of muscle platform which may possibly be attachment areas for adjustor muscles. On either side of muscle field, outside dental plates, are pair of arcs of pustules, presumably delimiting inner edge of *vascula genitalia*. These structures are seen in several specimens but particularly BB37262 (Fig. 92) (Fig. 8). Brachial valve interior with stout tusk-like brachiophores and small shallow sockets defined by fulcral plates. Cardinal process simple low ridge, rising from fairly thick notothyrial platform. Quadripartite adductor scars with posterior pair smaller than anterior. Impressions of *vascula genitalia* seen outside muscle field in several specimens.

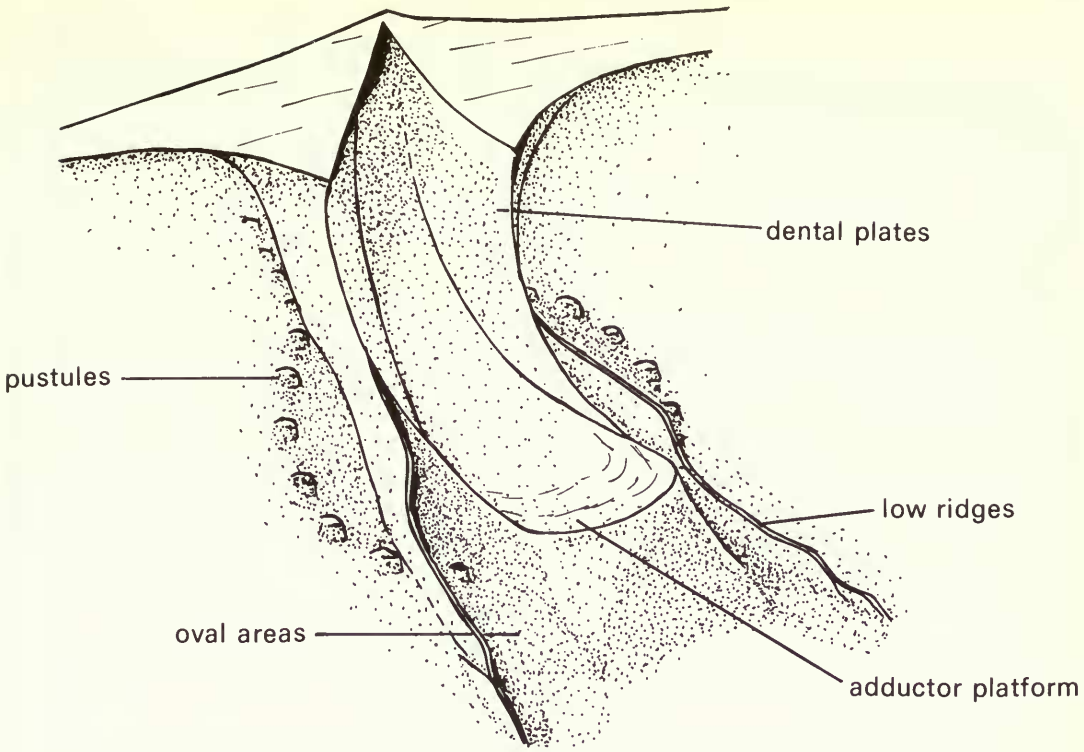

Fig. 8 Diagrammatic view of the ventral interior of *Platystrophia anomala* sp. nov.

TYPE MATERIAL

	length	width
External mould of a pedicle valve, holotype, BB37256	—	c. 15
External mould of a pedicle valve, BB37258	—	c. 13
External mould of a pedicle valve, BB37259	—	20·0
External mould of a brachial valve, BB37260	8·0	14·8
External mould of a brachial valve, BB37261	7·3	9·8
Internal mould of a pedicle valve, BB37263	—	17·6

DISCUSSION. Several authors have attempted to establish a logical way to aid identification of *Platystrophia* species. Cumings (1903) divided the genus into three species groups on the basis of the number of ribs in the ventral sulcus of early growth stages, and termed unicostate, bicostate, and tricostate (Schuchert & Cooper 1932 : 67). McEwan (1920) elaborated upon earlier work, and subdivided the biplicate (bicostate) group into four subgroups based on the development of further ribs in the sulcus after the initial pair.

Williams (1962 : 126 and 1963 : 371) and Wright (1964 : 206) both pointed out the artificial nature of the 'pigeon-hole' classification, because specimens which would belong to different species groups can be found within a single population sample. Under McEwan's classification the Glyn Ceiriog *Platystrophia* belongs to the unicostate group but those specimens which do develop extra ribs in the sulcus could be placed in the tricostate group. All variations within the sample are found in a single horizon so there is no question of an evolutionary sequence being involved. Cumings (1903 : 11) states that practically any group of *Platystrophia* may produce an occasional unicostate individual but in the Glyn Ceiriog sample 1–3 costae are present in the sulcus of 15, 4 and 0 pedicle valves at the 5 mm growth stage so the unicostate condition is dominant. The sample shows that 4 out of 19 pedicle valves have two ribs in the sulcus at the 5 mm growth stage and that by 6 mm a third rib may be intercalated and at that growth stage 3 out of 15 valves have three ribs.

The unicostate condition serves to distinguish the Glyn Ceiriog specimens from contemporary species such as *P. scotica*, *P. fissicostata*, *P. camerata* and *P. lutkevichi*, all of which belong to the bicostate group, and *P. molaris* which is a tricostate form. The shells which most closely resemble this Welsh species are members of the tricostate group, especially the 'high fold' variety in which the fold has become compressed and the lateral ribs tend to disappear. However, the fold on the Dolhir specimens is not compressed and the lateral ribs remain as strong as the median costae, thus the Glyn Ceiriog *Platystrophia* is regarded as a separate species.

Platystrophia lutkevichi Alichova ***costellata*** subsp. nov.
Figs. 98–102

1922 *Orthis* (*Platystrophia*) *biforata* Schlotheim; Wills & Smith: 191.
1922 *Orthis* (*P.*) *biforata* var. *fissicostata* M'Coy; Wills & Smith: 191 (pars).

DIAGNOSIS. *Platystrophia* differing from *P. lutkevichi* Alichova in developing costellate ornament on flanks of valves.

MATERIAL AND HORIZON. Internal and external moulds of 5 pedicle and 6 brachial valves from near the top of the Cyrn-y-brain Formation, 5–12 metres below junction with the Plas Uchaf Formation.

DESCRIPTION. Strongly dorsi-biconvex shells of subrectangular outline; maximum width near hinge-line, cardinal angles rectangular or roundedly obtuse. Pedicle valve over two-thirds as long as wide and one-third as deep as long. Lateral profile convex; anterior profile convex on flanks with broad, flat median sulcus about one-half as wide as maximum valve width, at anterior margin. Interarea short, curved, apsacline; delthyrium open. Brachial valve four-fifths as long as wide and over two-fifths as deep as long. Strongly convex in lateral profile; anterior profile with high, steep sided, flat-topped fold separating convex flanks. Interarea short, curved, anacline; notothyrium open. Ornament of 6–9 subangular costae on flanks of 1, 3, 0, 2 brachial valves respectively at 5 mm growth stage; these may increase by branching at about 10 mm growth stage. Sulcus with 2 initial costae but further ribs are intercalated by 5 mm growth stage; fold initially with 3 ribs which may branch by 5 mm growth stage.

Ventral interior with strong teeth supported by slightly convergent dental plates whose anterior ends bound elongate, suboval muscle field, three-fifths as long as wide, two-fifths as long as valve and situated on thickened platform of secondary shell. Dorsal interior with strong tusk-like brachiophores and simple, ridge-like cardinal process on thickened notothyrial platform, with very abrupt anterior edge. Subquadrate muscle field, with posterior scars smaller than anterior, divided longitudinally by narrow median furrow. Strongly impressed ribbing obscures mantle canals.

TYPE MATERIAL

	length	width
Internal mould of a brachial valve, holotype, BB37269 . . .	28·0	36·2
Internal mould of a brachial valve, BB37271	16·4	18·9
Internal mould of a pedicle valve, BB37272	18·3	—
Internal mould of a pedicle valve, BB37273	11·6	c. 16

DISCUSSION. These fairly large specimens are all members of the bicostate species group and can be divided into subgroups, A, C and D according to McEwan's classification, again exposing the weakness of such a subdivision. The sample shows that by the 5mm growth stage 1 out of 5 specimens has 3 ribs in the sulcus, and by the 10mm growth stage 3 out of 5 specimens have 4 ribs, 1 out of 5 has 5 ribs and 1 out of 5 has 6 ribs. On the fold at the 5mm growth stage, 6 out of 6 specimens still have 3 ribs, and by the 10 mm growth stage 3 out of 6 have 3 ribs, 2 out of 6 have 5 ribs and 1 out of 6 has 6 ribs. One large specimen has 7 ribs on the fold at 20 mm and another has 8 ribs at 15 mm. A similar variation in rib development was described in the *Platystrophia* from the Portrane Limestone by Wright (1964 : 207) but the Cyrn-y-brain specimens differ in that 6 out of 11 specimens are seen to develop costellae on the flanks. This costellate

condition is developed on shells within the same size range as the Portrane specimens and also serves to distinguish the Welsh form from other known subspecies of *P. lutkevichi*, i.e. *P. lutkevichi lutkevichi* Alichova, 1963 and *P. lutkevichi satura* Oraspold, 1959, which it resembles in most other respects. *P. camerata* Twenhofel 1928 is a costellate form but has a rounded rather than high, flat-topped fold. *P. fissicostata* (M'Coy, 1852 : 193) is described as having 6–15 lateral ribs which branch irregularly into two or four, however, the figured specimens (Davidson, 1864; pl. 38 figs 17, 19, not figs 15, 16: see Cocks 1978 : 197) show no such branching ribs on the flanks, and it has been said that M'Coy's original material contained a large quantity of *Oxoplecia* as well as various species of *Platystrophia* (Wright 1964 : 208).

Family **CREMNORTHIDAE** Williams, 1963

Subfamily **CREMNORTHINAE** Williams, 1963

CREMNORTHIS Williams, 1963

Cremnorthis sp.

Figs 103–105

MATERIAL AND HORIZON. Internal moulds of two tiny brachial valves, BB37275–6, from the same locality in the lower part of the Dolhir Formation, 50 m above the Tyn-y-twmpath Member. Lengths 0·9 and 1·0, widths 1·2 and 1·4 respectively.

DESCRIPTION. Moderately convex, subrectangular brachial valves almost three-quarters as long as wide and about one-fifth as deep as long; maximum width anterior to hinge-line, cardinal angles obtuse. Interarea flat, anacline, about one-tenth as long as valve. Interior with broad, bulbous cardinal process passing anteriorly into low, thin median septum which extends almost to valve margin. Stout brachiophores supported by thin, slightly divergent bases; fulcral plates well developed. Exterior unknown but internal impressions indicate about 18 ribs at 1 mm growth stage. Pedicle valve unknown.

DISCUSSION. *Cremnorthis* is poorly known from the Ashgill, the only previous record being from the Killey Bridge Formation of Pomeroy (Mitchell 1977 : 47). Both these samples are too small to allow specific identification to be made, although the species are apparently different from the *C. parva* Williams and *C. uhakuana* Hints stocks. The internal impression of the ornament shows the Glyn Ceiriog form to be more coarsely ribbed than *C. uhakuana* which has 30 ribs at the 1 mm growth stage on the brachial valve. The differences with the type species, *C. parva*, are less noticeable but the cardinalia of the Glyn Ceiriog form are apparently less robust although this may be due to the small size of the present specimens and more material is needed before a statistical comparison can be carried out.

Family **SCENIDIIDAE** Kozlowski, 1929

SKENIDIOIDES Schuchert & Cooper, 1931

Skenidioides cf. ***asteroideus*** (Reed 1917)

Figs 106–118

?1908 *Rhynchonella* cf. *Lewisi* Davidson; Groom & Lake: 577.
cf. 1917 *Scenidium Lewisi* Davidson, var. *asteroidea* Reed: 921, pl. 22, figs 1–3.

MATERIAL AND HORIZON. Internal and external moulds of 22 brachial and 50 pedicle valves from throughout the Dolhir Formation and from the Glyn Limestone Member at the base of the Glyn Formation.

DESCRIPTION. Ventri-biconvex shells of triangular to subpentagonal outline with maximum width along hinge-line; cardinal angles acute to rectangular. Pedicle valve almost four-fifths as long as wide; posterior edges of valve form straight-sided obtuse angle at umbo. Lateral profile sub-pyramidal to strongly convex; anterior profile convex, flattened slightly laterally but with weakly developed median fold in large specimens. Interarea well developed, just over two-fifths as long

as valve, curved or flatfly apsacline. Brachial valve gently convex; median sulcus broad, gently rounded. Ornamentation of even, sub-rounded ribs, ventral fold with fascile of 2–4 ribs by 3 mm distance from umbo in 8/9 specimens, the other having a solitary median rib. External costellae developed by this growth stage in most specimens to give total rib counts of 12–21. Brachial valve with internal costellae only, one costella per sector, also developed by 3 mm growth stage.

Ventral interior with spondylium about one-third as long as valve; short, thick supporting septum variably developed. Dorsal cardinalia with simple cardinal process; well developed sockets bounded by slightly curved fulcral plates; brachiophore bases converge on to median septum which extends for almost seven-tenths of valve length. Faint adductor muscle field, about as long as wide, bisected longitudinally by median septum.

DIMENSIONS

	length	width
Internal mould of a brachial valve, BB37277	3·1	4·8
Internal mould of a brachial valve, BB37278	3·8	5·6
Internal mould of a pedicle valve, BB37279	5·8	6·8
External mould of a pedicle valve, BB37280	5·8	6·9
Internal mould of a pedicle valve, BB37281	8·0	8·6
Internal mould of a pedicle valve, BB37282	3·3	4·5
Internal mould of a pedicle valve, BB37284	8·5	8·7

DISCUSSION. One important consideration used in the differentiation of species of *Skenidioides* is the number of ribs on the pedicle valve. The Glyn Ceiriog species has 12–21 ribs at the 3 mm growth stage on 1, 4, 3, 6, 3, 4, 1, 4, 1, 1 pedicle valves respectively. It can be most closely compared to *S. asteroideus* (Reed, 1917), *S. costatus* Cooper, 1956 and *S. scoliodus* Temple, 1968, all of which have rib counts within the same range as that for the Glyn Ceiriog form.

S. costatus, with 13–21 ribs, is very similar in appearance to the present specimens but possesses a strong median costa which forms a prominent fold, and from Cooper's figured specimens (1956 : pl. 97D, figs 38–48) it would appear to have a more alate outline although no data are available to test this. However, Williams (1963 : 375) describes *S.* cf. *costatus*, from the Caradoc of the Bala district, which does not differ significantly from the Glyn Ceiriog form in comparisons of length : width of the pedicle valves. *S. scoliodus* has 12–20 ribs, but differs from the Glyn Ceiriog species in having a pronounced median rib and on comparisons of length : width of pedicle valves the Keisley form is significantly wider ($0{\cdot}002 > P > 0{\cdot}001$). No figures are available for Reed's material, but a similar comparison with *S. cf asteroideus* from the Portrane Limestone

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Figs 126–127, 132–133, 137, 140–142, 146–147, 149 *Dalmanella* cf. *testudinaria* (Dalman). Glyn Formation. Figs 126, 127, BB37299, Internal mould and latex cast of a brachial valve, ×3·9, loc. G3; Fig. 141, BB37302, Internal mould of a pedicle valve, ×3·4, loc. G2. Dolhir Formation: Fig. 132, BB37305, Internal mould of a brachial valve, ×6, loc. D14; Fig. 133, BB37300, Latex cast of the exterior of a brachial valve, ×5·3, loc. D14; Fig. 137, BB37301, Internal mould of a brachial valve, ×3·8, loc. D14; Fig. 140, BB37306, Latex cast of the exterior of a brachial valve, ×5·3, loc. D14; Fig. 142, BB37304, Internal mould of a pedicle valve, ×5·2, loc. D14; Fig. 146, BB37308, Internal mould of a brachial valve, ×4, loc. D6; Fig. 147, BB37303, Latex cast of the exterior of a pedicle valve, ×5, loc. D14; Fig. 149, BB37307, Internal mould of a brachial valve, ×5·4, loc. D6.

Figs 138–139, 143–145, 148, 150 ?*Dalmanella* sp. Cyrn-y-brain Formation: Figs 138, 139, BB37317, Internal mould and latex cast of a brachial valve, ×3·5, ×3·1, loc. C1; Figs 143, 144, BB37315, Internal mould and latex cast of a brachial valve, ×3·3, loc. C1; Fig. 145, BB37315, Latex cast of the exterior of a brachial valve, ×3·3, loc. C1; Figs. 148, 150, BB37318, Latex cast and internal mould of a brachial valve, ×3·5, ×4, loc. C1.

Figs 128–131, 134–136, 151 ?*Howellites* sp. Dolhir Formation: Figs 128, 129, BB37320, Internal mould and latex cast of a brachial valve, ×4·3, loc. D10; Figs 130, 131, BB37319, Internal mould and latex cast of a brachial valve, ×4·1, ×4, loc. D2; Figs 134, 135, BB37323, Internal mould and latex cast of a pedicle valve, ×2·3, ×2·4, loc. D2; Fig. 136, BB37321, Latex cast of the exterior of a brachial valve, ×3·6, loc. D1; Fig. 151, BB37322, Latex cast of the exterior of a brachial valve, ×4·3, loc. D2.


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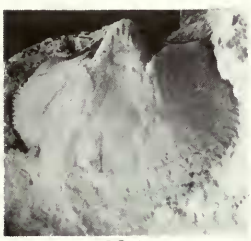
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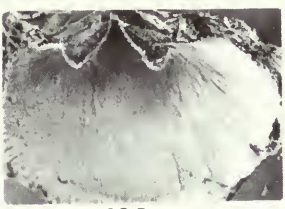
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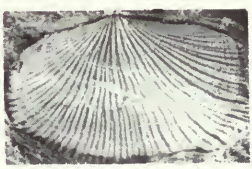
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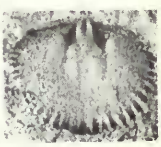
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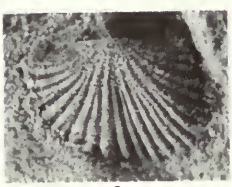
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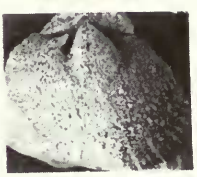
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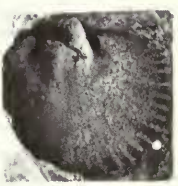
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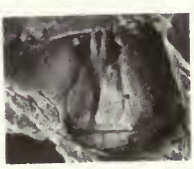
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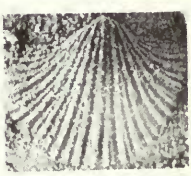
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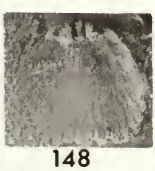
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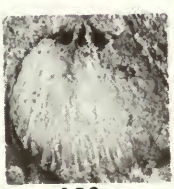
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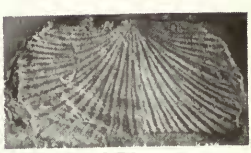

151

(Wright, 1964 : 212) shows that there is no significant difference between it and the Glyn Ceiriog form. The Portrane form also has a nearly identical ornament to the Welsh species, with 11–19 ribs on 1, 4, 4, 4, 3, 2, 6, 1, 1 pedicle valves respectively at the 2 mm growth stage. Thus the Glyn Ceiriog *Skenidioides* is regarded as being very closely related to *S.* cf. *asteroideus*.

The following data were obtained for the sample:
Length (*l*) : *width* (*w*) *of pedicle valve:* n = 29; $\overline{l}$(var. l) = 5·38 (3·773) mm; $\overline{w}$(var. w) = 6·93 (4·456) mm; r = 0·873; a(var. a) = 1·086 (0·00963).

Superfamily **ENTELETACEA** Waagen, 1884
Family **SCHIZOPHORIIDAE** Schuchert & Le Vene, 1929
Subfamily **DRABOVIINAE** Havlíček, 1950

HIRNANTIA Lamont, 1935

Hirnantia sagittifera (M'Coy, 1851)?
Figs 119–125

?1851 *Orthis sagittifera* M'Coy: 398.
1908 *Orthis* cf. *sagittifera* M'Coy; Groom & Lake: 573.
1922 *Orthis* (*Heterorthis*?) *sagittifera* M'Coy; Wills & Smith: 74.

MATERIAL AND HORIZON. Internal and external moulds of 4 pedicle and 7 brachial valves from the Plas Uchaf Formation and the Glyn Formation.

DESCRIPTION. Ventribiconvex shells of subcircular to transversely subelliptical outline; maximum width about mid-valve; cardinal angles obtuse. Pedicle valve over seven-tenths as long as wide and over one-quarter as deep as long; evenly convex in both profiles. Interarea curved, apsacline; delthyrium narrow, open; small pedicle callist present in some specimens. Brachial valve about seven-tenths as long as wide and almost one-fifth as deep as long; moderately convex in both profiles but anterior profile modified by broad, shallow, anteriorly expanding sulcus. Interarea short, flat, anacline; notothyrium open. Ornamentation of fine subangular costae and costellae with density of about 3 ribs/mm at 5 mm growth stage on brachial valve.

Ventral interior with strong teeth supported by widely divergent dental plates (about 70°). Poorly defined, cordate muscle field about five-sixths as long as wide and one-half as long as valve with diductor scars extending slightly beyond adductors. Dorsal interior with cardinal process differentiated into bilobed myophore and slender shaft, extending for about one-quarter of valve length; brachiophores with bases diverging anteriorly at about 50°; sockets defined by fulcral plates. Notothyrial platform not developed to any extent. Faintly impressed adductor muscle field about seven-tenths as long as wide and less than one-half as long as valve, consisting of two pairs of subcircular scars on either side of slight median thickening of valve floor.

DIMENSIONS

	length	width
Internal mould of a brachial valve, BB37292	—	8·3
External mould of a brachial valve, BB37293	3·6	5·0
Internal mould of a brachial valve, BB37295	5·9	6·5
Internal mould of a pedicle valve, BB37298	7·8	12·1

DISCUSSION. *Hirnantia sagittifera* (M'Coy, 1851) is a widespread species in the uppermost Ashgill of the British Isles, Europe and North Africa: as a member of the nearly ubiquitous *Hirnantia* fauna, and from previous authors' descriptions, it would appear to be a fairly variable species. For example, Temple (1965 : 395) describes ventri-biconvex, transversely elongated shells with a short, bilobed cardinal process and fulcral plates, but Bergström (1968 : 11) describes biconvex shells with a simple cardinal process and without fulcral plates, while Williams (1951 : 97) describes subcircular dorsi-biconvex shells with a simple cardinal process and fulcral plates. The Glyn Ceiriog and Plas Uchaf specimens fall within the range of variation concerning shell shape and nature of cardinalia covered by other descriptions, being subcircular to transversely elliptical

ventri-biconvex with a bilobed cardinal process and having fulcral plates. Some difficulty was encountered, with small specimens in particular, in distinguishing them from certain species of *Pionodema* and *Salopina*.

Family **DALMANELLIDAE** Schuchert, 1913

From the work of Williams and Wright (1963) on the '*Orthis testudinaria* Dalman' group it is evident that generic assignment in this group is primarily based on the details of the cardinalia and ventral muscle field.

Thus only the best specimens may be used, as even slight crushing hazards the generic identification of any individual specimen. In this account of the dalmanellids of Glyn Ceiriog, and the Dolhir Formation in particular, only those specimens which show the least effects of tectonic distortion have been considered. Because of this, the sample sizes quoted in descriptions represent only a fraction of the total sample recovered from the various Ashgill strata, where the dalmenellids by far out-number any other group of brachiopods.

DALMANELLA Hall & Clarke, 1892

Dalmanella cf. ***testudinaria*** (Dalman, 1828)
Figs 126–127, 132–133, 137, 140–142, 146–147, 149

cf. 1828 *Orthis testudinaria* Dalman: 115, 117, pl. 2, fig. 4.
1908 *Orthis testudinaria* Dalman; Groom & Lake: 573.
1922 *Orthis* (*Dalmanella*) cf. *testudinaria* Dalman; Wills & Smith: 187, 191.

Material and horizon. Internal and external moulds of 12 pedicle and 21 brachial valves from the Dolhir Formation, Glyn Formation and Cyrn-y-brain Formation.

Description. Ventri-biconvex shells of sub-circular outline with maximum width anterior to hinge-line; cardinal angles rounded, obtuse. Pedicle valve almost nine-tenths as long as wide, hinge-line almost four-fifths of maximum valve width; thickness averaging over one-third of valve length. Lateral profile with maximum convexity near umbo; anterior profile with median portion more convex than flanks. Interarea curved, apsacline, about one-seventh as long as wide and one-eighth as long as valve; delthyrium open, pedicle callist present. Brachial valve over four-fifths as long as wide and one-tenth as deep as long; gently convex in both profiles, anterior profile modified by shallow median sulcus which expands anteriorly. Interarea short, anacline, less than one-tenth as long as wide; notothyrium open. Costellate ornament with 4–5 ribs per mm at 2 mm anterior to dorsal umbo.

Ventral interior with stout teeth supported by strong dental plates which continue forward to define muscle field four-fifths as wide as long and over two-fifths as long as valve. Median adductor scar slightly shorter than bounding diductor lobes and occupying almost one-third of total width of scar. Crural fossettes present on inner surfaces of teeth. Dorsal interior with cardinalia extending for one-quarter of valve length, comprising bilobed (?) cardinal process with weakly developed shaft on low notothyrial platform; tops of brachiophores diverging anteriorly at less than 60°, bases diverging along valve floor at slightly, but not significantly, smaller angle. Fulcral plates and crural pits variably developed. Subquadrate adductor field about two-fifths as long as valve, with posterior pair of scars smaller than anterior; low median ridge divides muscle field longitudinally.

Dimensions

	length	width
Internal mould of a brachial valve, BB37299	7·8	8·8
External mould of a brachial valve, BB37300	2·8	3·1
Internal mould of a brachial valve, BB37301	2·8	3·2
Internal mould of a pedicle valve, BB37302	6·2	7·0
External mould of a pedicle valve, BB37303	4·5	5·0
Internal mould of a brachial valve, BB37305	3·2	4·3
External mould of a brachial valve, BB37306	2·5	3·2

DISCUSSION. The Glyn Ceiriog *Dalmanella* has its closest relatives in *D. testudinaria* (Dalman, 1828) and *D. portranensis* Wright, 1964. A comparison of the data for the Welsh shells with that for both the Irish and Swedish species reveals that, although the Glyn Ceiriog valves are smaller, there is no significant difference in the shape of either the brachial or pedicle valves of any of the three forms. However, a similar comparison shows that *D. portranensis* is significantly deeper ($0{\cdot}01 > P > 0{\cdot}002$) in ventral profile than the Glyn Ceiriog *Dalmanella*.

Although the more important rib relationships cannot be properly studied on the available Glyn Ceiriog exteriors, which are poorly preserved especially in the early growth stages, the density of 3–4 ribs per mm, measured at 5 mm anterior to the dorsal umbo, is not significantly different from that in the other two forms.

The cardinalia of the Glyn Ceiriog valves extends further forward, relative to the valve length, than in *D. testudinaria*, with the percentage ratios of length being *D. testudinaria*, 5 valves—16, 19, 19, 20, 20% and Glyn Ceiriog *Dalmanella*, 10 valves—18, 20, 21, 23, 24, 25, 25, 26, 26, 26%.

A Rank Sum Test on these data shows a significant difference ($P < 0{\cdot}001$) between the two samples. The figures for the Glyn Ceiriog *Dalmanella* are practically identical to those given by Wright (1964 : 222) for *D. portranensis*.

The posterior edges of the brachiophores of 10 Welsh specimens have a mean angle of divergence of 57·5° (var. 56·94) while their bases diverge at a mean angle of 51·0° (var. 37·78). No significant difference was found in these attributes between this sample and that for *D. testudinaria* but the brachiophore bases of *D. portranensis*, which produced values of 58·5° (var. 43·4) were found to be significantly more divergent ($0{\cdot}05 > P > 0{\cdot}02$).

The dorsal adductor muscle field is similarly disposed in all three forms, with the anterior scars being larger than the posterior pair, but that of the Welsh species extends for a significantly greater proportion of valve length than that of the other species ($0{\cdot}05 > P > 0{\cdot}02$). Comparisons of the ventral muscle fields show that, although the Glyn Ceiriog form is apparently closer to *D. portranensis*, it is not significantly different from either the Irish or Swedish species.

The sample of Glyn Ceiriog *Dalmanella* appears to be intermediate between *D. portranensis*, from which it differs in having more narrowly divergent brachiophore bases and a shallower pedicle valve, and *D. testudinaria* which has significantly shorter cardinalia. However, it is considered that the sample is inadequate and the erection of a new species or subspecies would not be justified, therefore the specimens are best left as being comparable to *D. testudinaria* which is the closer of the two related forms, differing significantly in only the one character whereas *D. portranensis* differs in two characters.

The data for *D. testudinaria* are taken from Williams & Wright (1963 : 30, 31).

The following statistical data have been obtained for the sample.

Pedicle Valves

Length (l) : width (w), n = 12; $\bar{l}$(var. l) = 4·51 (1·446) mm; $\bar{w}$(var. w) = 5·18 (2·052) mm; r = 0·95; a(var. a) = 1·191 (0·0139); $\overline{\log_e l}$(var. $\log_e$l) = 1·47) (0·0687); $\overline{\log_e w}$(var. $\log_e$w) = 1·61 (0·0736); r_e = 0·951; α(var. α) = 1·035 (0·0102).

Length (l) : thickness (d), n = 12; $\bar{l}$(var. l) = 4·51 (1·446) mm; $\bar{d}$(var. d) = 1·57 (0·212) mm; r = 0·743; a(var. a) = 0·382 (0·00653); $\overline{\log_e l}$(var. $\log_e$l) = 1·47 (0·0687); $\overline{\log_e d}$(var. $\log_e$d) = 0·41 (0·083); r_e = 0·751; α(var. α) = 1·096 (0·0523).

Length : width of muscle field, 8 valves—67, 74, 75, 78, 79, 90, 90, 93%

Length of muscle field : length of valve, 8 valves—32, 38, 40, 40, 42, 43, 44, 44%

Brachial Valves

Length (l) : width (w), n = 15; $\bar{l}$(var. l) = 4·31 (2·322) mm; $\bar{w}$(var. w) = 5·24 (2·571) mm; r = 0·866; a(var. a) = 1·052 (0·0213); $\overline{\log_e l}$(var. $\log_e$l)= 1·4 (0·118); $\overline{\log_e w}$($\log_e$w) = 1·61 (0·090); r_e = 0·873; α(var. α) = 0·872 (0·0139).

Length : width of interarea, 7 valves—7, 8, 9. 9, 10, 10, 16%

Length : width of muscle field, 10 valves—61, 62, 62, 63, 65, 65, 67, 67, 68%.

Length of muscle field : length of valve, 10 valves—55, 57, 60, 61, 62, 62, 64, 64, 67, 68%.

?***Dalmanella*** sp.

Figs 138, 139, 143–145, 148, 150

MATERIAL AND HORIZON. Internal and external moulds of 3 brachial valves from the Cyrn-y-brain Formation. Internal dimensions; BB37315, l = 6·0, w = 5·5; BB37317 l = 6·2, w = 5·0; BB37318, l = 5·5, w = 5·4.

DESCRIPTION. Brachial valve elongately subcircular, maximum width about nine-tenths of valve length, situated about mid-valve; cardinal angles obtuse; hinge-line about three-fifths of maximum width; depth almost one-fifth of valve length. Both profiles evenly convex except for narrow median sulcus indenting anterior profile. Interarea flat, anacline, about one-fifth as long as wide and one-tenth as long as valve; notothyrium open. Ornament with 5 subangular costae and costellae per mm, 2 mm anteromedianly from umbo.

Ventral interior unknown. Dorsal interior with cardinalia extending for less than one-fifth of valve length; stout, undifferentiated cardinal process situated on greatly thickened notothyrial platform; posterior edges of brachiophores diverge anteriorly at about 55° and their bases at about 50°. Small sockets bounded by brachiophores and fulcral plates; crural pits very shallow. Adductor muscle field poorly defined but extending for about three-fifths of valve length and divided longitudinally by strong median ridge extending from notothyrial platform.

DISCUSSION. This distinctive species is characterized by its fairly deep brachial valve with its narrow sulcus which does not expand appreciably toward the anterior margin and it is also rather unusual in being longer than wide. Internally it differs from *Dalmanella* cf. *testudinaria* in having shorter cardinalia and a much thicker notothyrial platform. It bears a close resemblance to '*Dalmanella*' *biconvexa* Williams, 1951 from the basal Lower Llandovery of Haverfordwest, but the Cyrn-y-brain sample is too small for a statistical comparison to be carried out. The convexity of the brachial valve and short hinge-line suggests affinity with *Cryptothyris* (Bancroft, 1945) but this is best known from the Caradoc and more material is required before these specimens can be unequivocally assigned to that genus.

HOWELLITES Bancroft, 1945

?*Howellites* sp.

Figs 128–131, 134–136, 151

1908 *Orthis elegantula* Dalman; Groom & Lake: 527, 577.
1922 *Orthis* (*Dalmanella*) *elegantula* (?) Dalman; Wills & Smith 187, 191.

MATERIAL AND HORIZON. Internal and external moulds of 19 pedicle and 21 brachial valves from the lower and middle parts of the Dolhir Formation.

DESCRIPTION. Ventri-biconvex shells of subcircular outline with maximum width anterior to hinge-line; cardinal angles rounded, obtuse. Pedicle valve over nine-tenths as long as wide and more than one-third as deep as long; hinge-line about nine-tenths as wide as valve; strongly convex in both profiles. Interarea strongly curved, apsacline, about one-fifth as long as valve, one specimen shows grooves diverging from umbo; delthyrium open, pedicle callist present. Brachial valve three-quarters as long as wide and one-tenth as deep as long; gently convex in both profiles with shallow, anteriorly expanding, median sulcus indenting anterior profile. Interarea very short, anacline; notothyrium open. Ornament of fine costae and costellae with density of 6–7 ribs per mm at 2 mm anteromedianly on brachial valves.

Ventral interior with strong teeth supported by thick dental plates bearing crural fossettes on inner surfaces. Muscle field approaching nine-tenths as long as wide and over one-third as long as valve; median adductor scar not enclosed by slightly longer diductors and occupying about one-third of total width of scar. Thick trunks of *vascula media* slightly divergent from anterior ends of diductor lobes. Dorsal cardinalia extending for almost one-quarter of valve length. comprising a differentiated bilobed and crenulated cardinal process on low notothyrial platform; tops of brachiophores diverge at about 56°, whereas bases diverge at 70°. Fulcral plates, in the strict sense, not normally developed but sockets usually supported by thickening of secondary shell; crural pits, if present, are normally very shallow.

Quadripartite adductor muscle field almost as long as wide and two-fifths as long as valve, usually defined by low ridges; subelliptical anterior pair larger than posterior pair. Broad median ridge extending from notothyrial platform bisects muscle field longitudinally.

DIMENSIONS

	length	width
Internal mould of a brachial valve, BB37319	6·6	13·2
Internal mould of a brachial valve, BB37320	6·7	7·2
External mould of a brachial valve, BB37321	5·5	8·9
External mould of a brachial valve, BB37322	4·2	6·9
Internal mould of a pedicle valve, BB37323	11·5	13·2

DISCUSSION. The generic assignment of these specimens has been the cause of some difficulty. The form of the cardinalia, in which the brachiophore bases are more widely divergent than the tops, the external ornament and the interior of the pedicle valve all suggest close affinities with three genera, *Resserella* Bancroft, 1928, *Dedzetina* Havlíček, 1950 and *Howellites* Bancroft, 1945, but differences and similarities can be found with each of these. Walmsley and Boucot (1971 : 495) state that the oldest undoubted *Resserella* species are of late *Llandovery* (C_3–C_6) age but they describe *R. sefinensis*, from beds of C_1 age, and they regard *Dedzetina* from the Ashgill of Bohemia as an ancestral form to *Resserella*. *Howellites* is best known from the Caradoc but unnamed species have been recorded from the Ashgill of the Cautley and Dent districts (Ingham, 1966 : 498) and Bala (Bassett, Whittington and Williams, 1966 : 263).

Howellites can be distinguished from *Resserella* and *Dedzetina* by its deeper, more strongly convex brachial valve, and sub-equal pairs of dorsal adductor scars. *Dedzetina* is distinguished from *Resserella* by its gently convex brachial valve with hypercline interarea and dorsal adductor muscle field in which the anterior scars are larger than the posterior pair, the reverse of the situation in *Resserella* (Walmsley and Boucot, 1971 : 50). However, the specimens figured by Walmsley and Boucot (1971 : pl. 91, figs. 1–4) as *Dedzetina macrostomoides* show the posterior scars to be larger than the anterior and, as pointed out by Sheehan (1973 : 62), the size differential is probably a variable feature.

The Glyn Ceiriog genus has a gently convex brachial valve and an adductor muscle field with posterior scars smaller than anterior, and in these respects resembles *Dedzetina* (as defined by Walmsley and Boucot, 1971 : 519) but differs in that the dorsal interarea is invariably anacline, like *Resserella* and *Howellites*. A form very similar to the Glyn Ceiriog shells, except for its more transverse pedicle valve, is *Resserella llandoveriana* Williams, 1951 from Meifod (Temple, 1970 : 22), but this species has been rejected from *Resserella* by Walmsley and Boucot (1971 : 495) although no alternative identification has been given.

If *Resserella* is confined to the Silurian, as is now generally accepted, then the present Ordovician specimens must be placed either in *Dedzetina* or *Howellites* and the form of the dorsal interarea seems to preclude attribution to *Dedzetina*. Hence the Glyn Ceiriog shells are placed in *Howellites*, but with strong reservations because the quite strong curvature of the ventral umbo and the form of the dorsal muscle field are more suggestive of the Resserellinae.

The problems encountered with the present specimens serve to highlight the difficulty in distinguishing between certain genera of the Dalmanellidae, particularly those extant during Ashgill times, because they lie on the border between the better-known Caradoc and Silurian stocks. Despite recent work on this family, much remains to be done to link up Ordovician and Silurian forms and on the variation within any given genus. *Dedzetina* is a poorly known genus with few described species, and its connection with older forms is unknown. The attitude of the dorsal interarea may turn out to be a variable feature and the genus may be closely related to *Howellites*. Such a study will require more material than is at present available, and certainly material that is better preserved than that available from Glyn Ceiriog.

The following data were obtained for the sample:

Pedicle Valves

Length (l) : width (w), n = 6; $\bar{l}$(var. l) = 6·2 (7·308) mm; $\bar{w}$(var. w) = 6·52 (11·366) mm; r = 0·998; a(var. a) = 1·247 (0·00168).

Length (l) : width of interarea (w), n = 6; $\overline{l}$(var. l) = 1·3 (0·408) mm; $\overline{w}$(var. w) = 6·78 (4·638) mm; r = 0·923; a(var. a) = 3·371 (0·4194); $\overline{\log_e l}$(var. $\log_e$l) = 0·15 (0·216); $\overline{\log_e w}$(var. $\log_e$w) = 1·87 (0·096); r_e(0·935); α(var. α) = 0·666 (0·014).
Width : length of muscle field, 6 valves—65, 76, 80, 83, 93, 94%.
Length of muscle field : length of valve, 5 valves—25, 29, 29, 34, 40%.
Brachial Valves
Length (l) : width (w), n = 17; $\overline{l}$(var. l) = 5·04 (1·145) mm; $\overline{w}$(var. w) = 6·61 (1·742) mm; r = 0·657; a(var. a) = 1·234 (0·0576); $\overline{\log_e l}$(var. $\log_e$l) = 1·60 (0·044); $\overline{\log_e w}$(var. $\log_e$w) = 1·87 (0·039); r_e = 0·668; α(var. α) = 0·941 (0·0327).
Length of valve (l) : length of cardinalia (c), n = 13; $\overline{l}$(var. l) = 5·08 (1·126) mm; $\overline{c}$(var. c) = 1·18 (0·05) mm; r = 0·758; a(var. a) = 0·211 (0·00172); $\overline{\log_e l}$(var. $\log_e$l) = 1·60 (0·043); $\overline{\log_e c}$(var. $\log_e$c) = 0·15 (0·036); r_e = 0·772; α(var. α) = 0·914 (0·03072).
Length of valve (l) : length of muscle field (m), n = 12; $\overline{l}$(var. l) = 5·02 (1·163) mm; $\overline{m}$(var. m) = 3·15 (0·554) mm; r = 0·907; a(var. a) = 0·690 (0·0084); $\overline{\log_e l}$(var. $\log_e$l) = 1·59 (0·045); $\overline{\log_e m}$ (var. $\log_e$m) = 1·1 (0·054); r_e = 0·911; α(var. α) = 1·095 (0·02032).
Width : length of muscle field, 10 valves—51, 60, 63, 63, 64, 64, 66, 67, 67, 77%.
Length of muscle field : length of valve, 10 valves—52, 58, 59, 59, 61, 62, 63, 64, 64, 67%.

EREMOTREMA Cooper, 1956

Eremotrema cf. *paucicostellatum* Mitchell, 1977
Figs 152–160

cf. 1977 *Eremotrema paucicostellatum* Mitchell: 59, pl. 10, figs 10–14.

Material and horizon. Twelve brachial valves and 10 pedicle valves from the lower part of the Dolhir Formation, and 1 pedicle valve from high up in the same formation. Most of the specimens are well preserved although some have suffered some crushing.

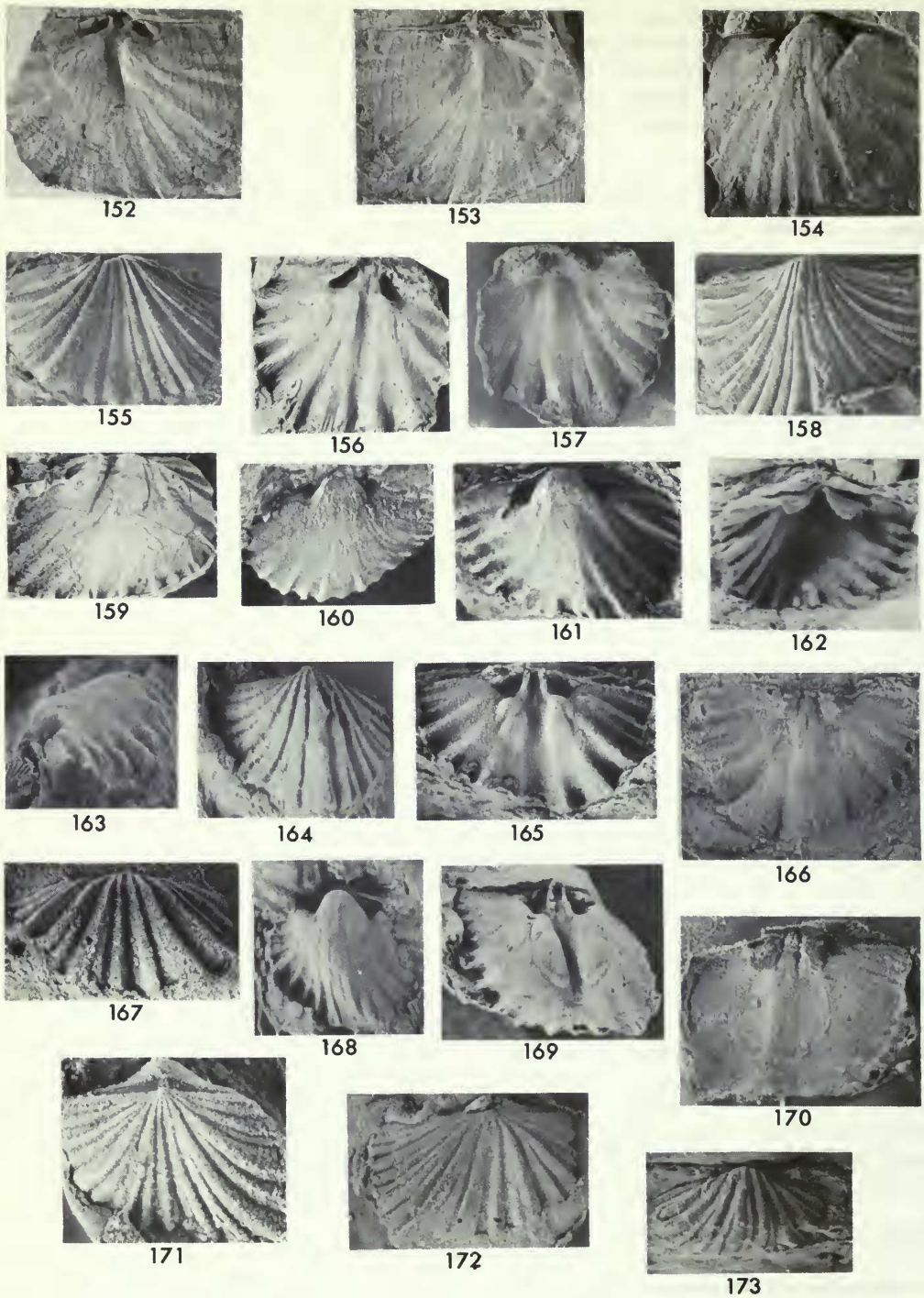
Description. Ventri-biconvex shells of subcircular outline with maximum width at or near mid-valve. Pedicle valve over nine-tenths as long as wide and one-fifth as deep as long; both profiles evenly convex; interarea slightly curved, apsacline, one-seventh as long as valve; delthyrium open. Brachial valve about nine-tenths as long as wide, and over one-tenth as deep as long; anterior profile gently convex on flanks with shallow median sulcus arising at umbo; interarea short, flat, anacline. Ornament of coarse angular costae and costellae yielding total counts of 14–20 ribs at 2 mm growth stage on 1, 0, 2, 1, 3, 0, 2 pedicle valves: internal and external costellae both developed by this stage.

Ventral interior with stout teeth supported by short receding dental plates. Sub-pentagonal muscle field about as wide as long and just over one-third as long as valve.

Dorsal interior with cardinal process differentiated into high, inflated, trilobed myophore, filling notothyrium, and short flattened shaft; widely divergent brachiophores supported by thickened bases converging on to median ridge and posteriorly supporting sockets; cardinalia nearly three-fifths as long as wide and extending anteriorly for one-fifth of valve length. Adductor muscle field about three-quarters as long as wide and divided by short thick ridge extending anteriorly from notothyrial platform for one-half of valve length.

Dimensions

	length	width
Internal mould of a brachial valve, BB37327	10·5	14·3
Internal mould of a brachial valve, BB37328	10·5	11·5
External mould of a brachial valve, BB37329	7·1	9·8
External mould of a pedicle valve, BB37330	7·5	10·0
Internal mould of a brachial valve, BB37331	c. 10	12·2
Internal mould of a pedicle valve, BB37332	6·3	9·2
Internal mould of a pedicle valve, BB37337	11·9	12·8



Figs 152–160 *Eremotrema* cf. *paucicostellatum* Mitchell. Dolhir Formation: Figs 152–3, BB37327, Internal mould and latex cast of a brachial valve, ×2·4, loc. D5; Fig. 155, BB37329, Latex cast of the exterior of a brachial valve, ×3·1, loc. D4; Figs 156–7, BB37328, Internal mould and latex cast of a brachial valve, ×3·8, loc. D2; Fig. 158, BB37330, Internal cast of the exterior of a pedicle valve, ×3·3, loc. D4; Fig. 159, BB37331, Internal mould of a deformed brachial valve, ×3·0,

Discussion. Only three species of *Eremotrema* have previously been described: *E. biconvexum* Cooper, 1956, *E. gracile* (Reed, 1917, emended Williams, 1962), and *E. paucicostellatum* Mitchell, 1977. Of the three, the Glyn Ceiriog species compares most closely with the last, having a similarly coarse ornament. Eight Glyn Ceiriog brachial valves yield total rib counts of 16, 18, 20, 20, 20, 20, 22, 22, ribs respectively at the 2 mm growth stage compared with 22 and 26 ribs on 3 and 1 brachial valves of *E. paucicostellatum* from Pomeroy. A density of 2 and 3 ribs per mm was observed on 7 and 2 Welsh pedicle valves respectively, measured 5 mm anteromedianly from the umbo. A single Pomeroy specimen had a density of 2 ribs per mm at the same stage. Another feature which distinguishes *E. paucicostellatum* from the two older species is its short, transverse cardinalia. Although the samples are too small for statistical comparisons, the cardinalia of the Glyn Ceiriog specimens do, on average, appear to be longer than for *E. paucicostellatum*. Other differences occur in the depth of the pedicle valve and relative length of the brachial valve, but these may be partly a result of the crushing suffered by some Glyn Ceiriog specimens. Thus the Welsh species and *E. paucicostellatum* are very similar in ornament but display some differences in shell shape.

RAVOZETINA Havlíček, 1974

Ravozetina silvicola (Temple, 1970) ***prima*** subsp. nov.
Figs 161–173

Diagnosis. Strongly ventri-biconvex *Ravozetina* with low fold on pedicle valve and well developed sulcus on brachial valve. Ribbing relatively simple, without development of third order costellae.

Material and horizon. Internal and external moulds of 37 pedicle and 47 brachial valves from the lower part of the Dolhir Formation, 25–50 m above the Dolhir Limestone.

Description. Small ventri-biconvex shells of transversely subquadrate outline; maximum width commonly anterior to hinge-line; cardinal angles rounded, obtuse. Pedicle valve over four-fifths as long as wide and over one-third as deep as long; lateral profile strongly convex, anterior profile with median maximum convexity reflecting low fold. Interarea short, about one-eighth as long as valve, curved, apsacline; delthyrium open. Brachial valve almost three-quarters as long as wide and over one-fifth as deep as long; lateral profile convex, anterior profile with convex flanks separated by well developed median sulcus which expands anteriorly; anterior commissure gently sulcate. Interarea very short, less than one-tenth as long as valve, flat, anacline; notothyrium open but almost entirely filled by cardinal process. Ornamentation of strong angular costae and costellae numbering 12–18 ribs at 2 mm growth stage on 10 pedicle valves. Ventral fold occupied by 3 primary costae; median one branching to produce costella on either side, lateral costae with external costellae developing at about 1·5 mm. On each flank 2 or 3 primary costae each produce one external costella and occasional internal costellae; capillae may develop in rib interspaces. Dorsal sulcus occupied by pair of narrow submedian costae which may produce internal costella in late growth stages. Sulcus bounded by pair of strong costae which branch internally; outside these 2 primary costae produce internal costellae and the occasional external costella. Prominent

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loc. D5; Fig. 160, BB37332, Internal mould of a pedicle valve, ×4·6, loc. D6. Dolhir Limestone Member: Fig. 154, BB37337, Internal mould of a pedicle valve, ×2·5, loc. L3.

Figs 161–173 *Ravozetina silvicola prima* subsp. nov. Dolhir Formation: Figs 161–2, BB37341, Internal mould and latex cast of a pedicle valve, ×7·5, ×7·4, loc. D5; Fig. 163, Lateral view of the same specimen, ×6·5, loc. D5; Fig. 164, BB37340, Latex cast of the exterior of a pedicle valve, ×6·9, loc. D5; Figs. 165–6, Holotype, BB37338, Internal mould and latex cast of a brachial valve, ×7·0, ×8·0, loc. D4; Fig. 167, BB37338, Latex cast of the exterior of the holotype, ×7·5, loc. D4; Fig. 168, BB37347, Internal mould of a pedicle valve, ×7·5, loc. D5; Figs 169–70, BB37343, Internal mould and latex cast of a brachial valve, ×6·9, loc. D4; Fig. 171, BB37344, Latex cast of the exterior of conjoined valves, ×6·3,loc. D4; Fig. 173, BB37341, Latex cast of the exterior of a pedicle valve, ×5·9, loc. D5; Fig. 172, BB37345, Latex cast of the exterior of a brachial valve, ×7·1, loc. D5.

growth lines seen on some specimens. Shell substance punctate; punctae seen all over internal and external surfaces.

Ventral interior with strong teeth supported by divergent, receding dental plates with occasional crural fossettes. Thick pedicle callist; muscle field lightly impressed, more or less confined to umbonal chamber, about as long as wide and about one-third as long as valve. Slightly raised adductor tract nearly two-fifths as wide as whole scar and only slightly shorter than diductors. Floor of valve slopes away steeply in front of muscle field, so that muscles are situated on thickened platform. *Vascula media* diverge from antero lateral corners of this platform. Dorsal interior with cardinalia extending for one-fifth of valve length and consisting of stout, undifferentiated, rarely bilobed or crenulated, cardinal process situated on thickened notothyrial platform. Shallow sockets bounded by fulcral plates and short, sturdy brachiophores with bases more divergent than tops. Crural pits not developed. Adductor muscle field five-sixths as long as wide and two-fifths as long as valve; bisected longitudinally by thick, rounded ridge extending from notothyrial platform; scars on either side divided by faint diagonal ridge so that posterior scar is smaller than anterior.

TYPE MATERIAL

	length	width
Internal mould of a brachial valve, holotype, BB37338 . . .	3·0	4·6
External mould of a brachial valve, holotype, BB37338 . . .	3·1	4·7
External mould of a pedicle valve, BB37340	3·0	3·7
Internal mould of a pedicle valve, BB37341	3·1	4·5
External mould of a pedicle valve, BB37341	3·2	4·6
Internal mould of a brachial valve, BB37343	4·1	—
External mould of conjoined valves, BB37344	—	4·8
External mould of a brachial valve, BB37345	—	4·5
Internal mould of a pedicle valve, BB37347	3·3	—

DISCUSSION. This small, distinctive species closely resembles *Ravozetina rava* (Marek & Havlíček, 1967) from the Kosov Formation (Upper Ashgill) of Czechoslovakia and *R. silvicola* (Temple, 1970) from the Lower Llandovery of Meifod, Wales. The latter was originally described as a subspecies of *R. rava* but subsequently assigned as a separate species by Havlíček (1977 : 145). The two forms are distinguished from one another by the stronger fold and sulcus and greater convexity of the valves of *R. silvicola*; this also has a more 'humped' ventral internal mould and stronger coarser ribbing. The Dolhir Formation specimens are more like *R. silvicola* but differ principally in their deeper pedicle valves. A 't'-test comparing length: depth data for 32 Glyn Ceiriog and 9 Meifod pedicle valves revealed that the Dolhir specimens are significantly deeper ($P < 0{\cdot}001$). A similar test showed that the ventral interarea of the Dolhir form is significantly shorter than that of *R. silvicola* ($P < 0{\cdot}001$).

Further, the Glyn Ceiriog shells are not seen to develop third order costellae which Temple records on brachial valves of his species (1970 : 21). A brachial valve has the following costellae:

Right side—1$\bar{a}$ 2$\bar{a}$ 3$\bar{a}$ 4$\bar{a}$

Left side—2$\bar{a}$ 3$\bar{a}$ 3$\bar{a}$ 4$\bar{a}$

This development is reflected in the pedicle valve.

Nevertheless, the general appearance of these two Welsh forms shows that they are morphologically very similar.

The following statistical data were obtained for the sample:

Pedicle Valves

Length (l) : width (w); n = 33; $\bar{l}$(var. l) = 3·24 (0·888) mm; $\bar{w}$(var. w) = 3·83 (0·777) mm; r = 0·578; a(var. a) = 0·935 (0·01878).

Length (l) : thickness (t), n = 32; $\bar{l}$(var. l) = 3·23 (0·918) mm; $\bar{t}$(var. t) = 1·22 (0·118) mm; r = 0·617; a(var. a) = 0·935 (0·00265).

Length (l) : length of interarea (h), n = 10; $\bar{l}$(var. l) = 3·57 (0·909) mm; $\bar{h}$(var. h) = 0·48 (0·024) mm; r = 0·913; a(var. a) = 0·162 (0·00054).

Length (l) : length of muscle scars (m), n = 20; $\bar{l}$(var. l) = 3·46 (0·903) mm; $\bar{m}$(var. m) = 1·12 (0·0792) mm; r = 0·764; a(var. a) = 0·296 (0·00202).

Brachial Valves

Length (l) : width (w), n = 38; $\bar{l}$(var. l) = 2·8 (0·619) mm; $\bar{w}$(var. w) = 3·79 (1·022) mm; r = 0·761; a(var. a) = 1·285 (0·0193).

Length of muscle field (l) : width of muscle field (w), n = 12; $\bar{l}$(var. l) = 1·31 (0·0863) mm; $\bar{w}$(var. w) = 1·52 (0·0924) mm; r = 0·864; a(var. a) = 1·035 (0·0272).

PORTRANELLA Wright, 1964

Portranella sp.

Figs 174–180

MATERIAL AND HORIZON. Moulds of 4 brachial valves and 1 pedicle valve from the Dolhir Formation, and 1 brachial valve from high up in the Cyrn-y-brain Formation.

DESCRIPTION. Ventri-biconvex shells of sub-rounded to transversely subelliptical outline, with maximum width anterior to hinge-line. Pedicle valve about three-quarters as long as wide and one-third as deep as long. Lateral profile with maximum convexity at umbo, which is slightly incurved; anterior profile moderately convex. Interarea short, curved, apsacline; delthyrium open. Brachial valve two-thirds as long as wide, gently convex with median sulcus moderately deep posteriorly but shallowing towards anterior margin. Interarea very short, anacline, cardinal process lobes protruding slightly from open notothyrium. Ornament of strong angular costae and costellae with brachial valve having 11 or 12 primary costae, median pair arising slightly later; branching first occurs in sector 1 with 1a rising quite early.

Ventral interior unknown. Dorsal interior with short, stout brachiophores whose divergent bases bound sockets. Trilobed myophore rising directly from thickened notothyrial platform; lateral lobes extend over posterior ends of brachiophores; no traces of shaft. Low rounded median ridge extending from notothyrial platform to about mid-valve. Few specimens show suggestion of faint punctation.

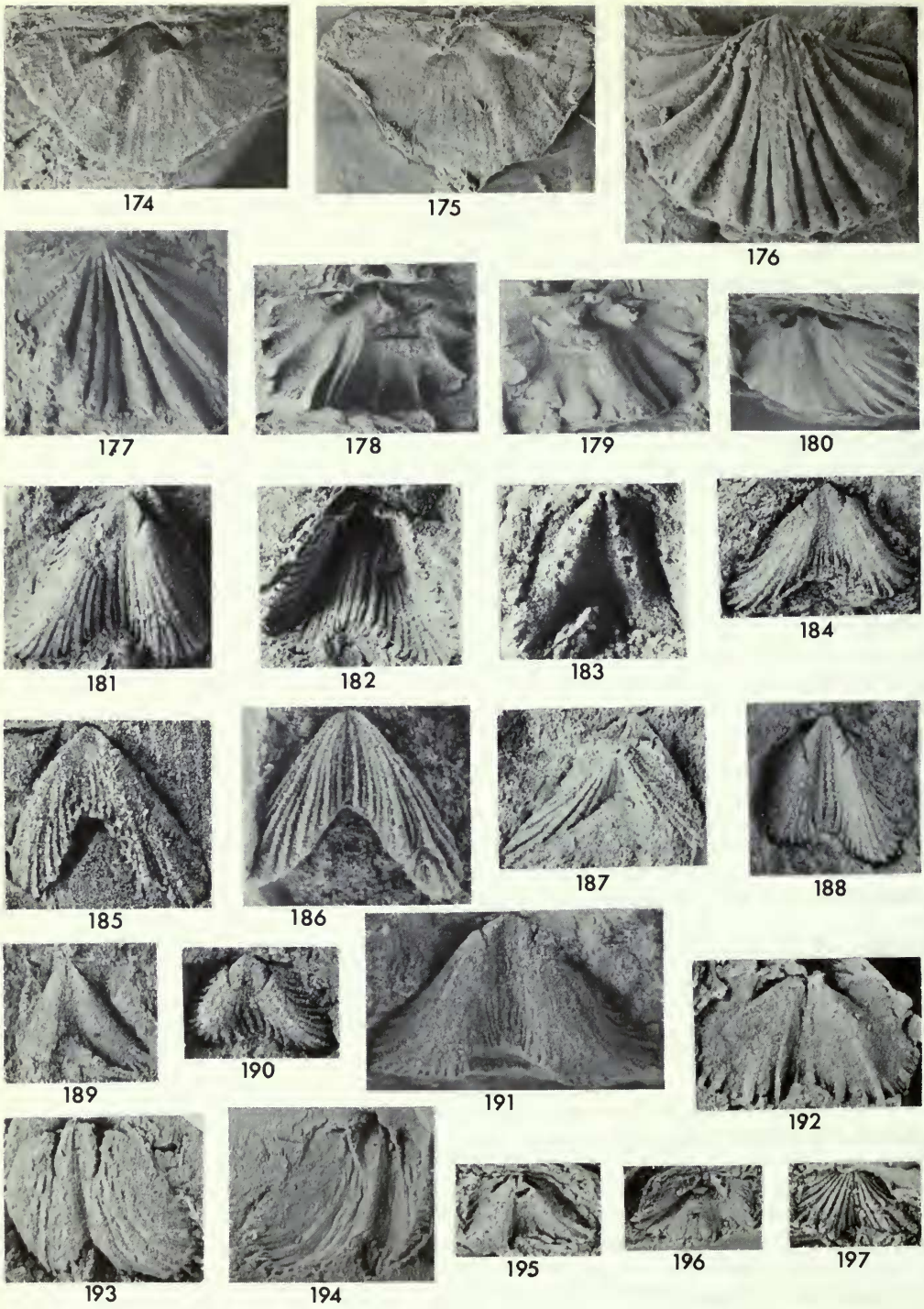
FIGURED SPECIMENS

	length	width
External mould of a brachial valve, BB37350	4·0	4·3
Internal mould of a brachial valve, BB37353	4·1	5·8
Internal mould of a brachial valve, BB37354	2·4	3·7
External mould of a pedicle valve, BB37355	4·9	6·4
Internal mould of a brachial valve, BB37356	6·2	10·2

DISCUSSION. With such a small sample it is difficult to make a complete comparison with the only species in the genus, *P. angulocostellata* Wright, 1964, from the Portrane Limestone. Both forms have similar dimensions, for example the Glyn Ceiriog pedicle valve has a thickness which is 35% of valve length, compared with 32, 33 and 39% of 3 Portrane specimens, 4 Glyn Ceiriog brachial valves have length : width ratios of 53, 61, 65, and 72% compared with 64, 44 and 75% for 3 Portrane valves.

The single Welsh pedicle valve has a density of 4 ribs per 2 mm at 5 mm growth stage; the Irish species has 3, 4 ribs per 2 mm on 3, 3 valves respectively. On the brachial valve the Glyn Ceiriog specimen has 3 ribs in the sulcus and 4 or 5 on the flanks at 3 mm growth stage while the Portrane valves have 2, 4 or 5 ribs in the sulcus and 6, 7 or 8 on the flanks at the same stage. The main difference in the ribbing of the two forms is the insertion of the costellae; in the Portrane specimens 4a° appears first, followed by 4ā and then 3ā, whereas in the Glyn Ceiriog specimen 3ā is preceded only by 1ā. So although the two forms are closely comparable there are some differences which may be significant if larger samples were available.

Wright (1964 : 168) placed *Portranella* in the Orthidiellidae partly on the apparent impunctate nature of the shell substance. However, a few of the Glyn Ceiriog specimens, those found in finer sediment, show what may prove to be a fine punctation especially along the internal impression of the ribs (see BB37354). This is not as well developed as the punctation seen in other stocks occurring in the Dolhir Formation with *Portranella*, but if indeed the specimens are



Figs 174–180 *Portranella* sp. Dolhir Formation: Figs 174, 175, BB37356, Internal mould and latex cast of a brachial valve, ×4·3, loc. D15; Fig. 176, BB37355, Latex cast of the exterior of a pedicle valve, ×5·8, loc. D2; Fig. 177, BB37350, Latex cast of the exterior of a brachial valve, ×8·0, loc. D3; Figs 178, 179, BB37354, Internal mould and latex cast of a brachial valve, ×8·6, loc. D3; Fig. 180, BB37353, Internal mould of a brachial valve, ×4·0, loc. D5.

punctate then the genus must be removed from the Orthidiellidae and is accordingly transferred to the Dalmanellidae.

Family **DICAELOSIIDAE** Cloud, 1948

DICOELOSIA King, 1850

Dicoelosia cf. ***indenta*** (Cooper, 1930)
Figs 181–191

1908 *Orthis biloba* Linnaeus: Groom & Lake: 572, 577.
cf. 1930 *Bilobites indentus* Cooper: 269, pl. 1, fig. 4.

MATERIAL AND HORIZON. Internal and external moulds of 17 brachial and 38 pedicle valves from throughout the Dolhir Formation and Glyn Formation.

DESCRIPTION. Concavo-convex shells with deeply invaginated anterior margin. Pedicle valve nearly nine-tenths as long as wide with mid-line length just over two-thirds of maximum valve length. Valve shallow with approximately even depth throughout its length; thickness less than one-third of valve length ('depth' and 'thickness' as defined by Wright, 1968 : 305). Outer flanks steeply sloping and slightly concave outwards; lobes narrow, rounded, diverging at about 55°. Hinge line just over two-fifths as wide as shell, cardinal extremities obtuse, with small ears. Interarea gently curved, apsacline, up to one-half as long as wide and one-fifth as long as valve; delthyrium open. Sulcus originating at umbo, gently rounded, typically about 1·1 mm wide at 2 mm growth stage; contained ribs not as strongly developed as on lobes. Brachial valve about seven-tenths as long as wide, very shallow with overall concave profile but flat or slightly convex umbonally. Interarea short, flat, anacline; notothyrium open. Shallow, gently curved sulcus originating at umbo, slightly broader than ventral sulcus, about 1·5 mm wide at 2 mm growth stage; again contained ribs weakly developed. Ornamentation of fine costae and costellae, 5, 6, 7 per mm on 7, 4, 3 brachial valves respectively at 2 mm anterolaterally from umbo, over crest of lobe. Fine punctae spread over shell surface.

Ventral interior with teeth supported by almost vertical, narrowly divergent dental plates which continue forward to bound cordate muscle field. This is slightly longer than wide and just over one-quarter as long as valve, with diductor scars extending slightly beyond, but not enclosing, raised median adductor scar. Dorsal interior with blade-like brachiophores diverging at about 70°; cardinal process with relatively long, slender shaft on unthickened notothyrial floor, with small ? myophore preserved at posterior end. Details of musculature and mantle canal system obscure. No evidence of dorsal ridges. Punctae prominent on embayments along margins of valve interiors but rarely seen on eminences; internal punctae much coarser than those seen on exterior of shells.

Figs 181–191 *Dicoelosia* cf. *indenta* Cooper. Dolhir Formation: Figs 181, 182, BB37357, Internal mould and latex cast of a pedicle valve, ×5·1, loc. D14; Fig. 183, BB37358, Internal mould of a brachial valve, ×4·1, loc. D14; Fig. 184, BB37366, Internal mould of a pedicle valve, ×5·2, loc. D14; Fig. 185, BB37360, Internal mould of a pedicle valve, ×5·2, loc. D14; Fig. 186, BB37361, Latex cast of the exterior of a pedicle valve, ×5·2, loc. D14; Fig. 187, BB37362, Latex cast of the exterior of a brachial valve, ×5·5, loc. D14; Fig. 188, BB37363, Internal mould of a pedicle valve, ×5·9, loc. D14; Fig. 189, BB37359, Internal mould of a brachial valve, ×4·9, loc. D14; Fig. 190, BB37367, Internal mould of a pedicle valve, ×5·0, loc. D14; Fig. 191, BB37364, Internal mould of a pedicle valve, ×5·3, loc. D14.

Figs 192–197 *Dicoelosia* sp. Dolhir Formation: Fig. 192, BB37371, Internal mould of a brachial valve, ×6·0, loc. D6; Figs 193, 194, BB37372, Internal mould and latex cast of a pedicle valve, ×4·8, loc. D1; Figs 195, 196, BB37374, Internal mould and latex cast of a brachial valve, ×6·4, loc. D5; Fig. 197, BB37374, Latex cast of the exterior of a brachial valve, ×6·4, loc. D5.

DIMENSIONS

	length	width
Internal mould of a pedicle valve, BB37357	4·7	5·4
Internal mould of a brachial valve, BB37358	5·8	6·5
Internal mould of a brachial valve, BB37359	3·1	3·5
Internal mould of a pedicle valve, BB37360	5·1	5·4
External mould of a pedicle valve, BB37361	5·1	5·5
External mould of a brachial valve, BB37362	4·9	5·3
Internal mould of a pedicle valve, BB37363	3·5	3·7

DISCUSSION. This species of *Dicoelosia* is characterized by narrow, fairly widely divergent lobes, deep emargination, concave brachial valve and faint ribbing in the dorsal sulcus. These would place it in the '*D. jonesridgensis*' group (Wright, 1968*a* : 281) along with *D. indenta* (Cooper, 1930). No statistical data are available for *D. jonesridgensis* Ross & Dutro, 1966 but it differs from the Glyn Ceiriog species in having a more strongly concave brachial valve, a single prominent rib on the crests of the lobes of each valve and in the development of dorsal ridges internally.

The type sample of *D. indenta* is inadequate to give sufficient data for a statistical comparison, but data are available for the sample from the Boda Limestone, (Ashgill) of Dalarna, Sweden which is regarded as being conspecific by Wright (1968*a* : 304). A comparison by 't' test of the maximum length : width of the pedicle valves shows no significant difference between the Dalarna and Glyn Ceiriog forms. The same is true for comparisons of maximum length : thickness of pedicle valves and maximum length : width of brachial valves. However, a marked difference is the absence from the Welsh form of the characteristic dorsal ridge seen in *D. indenta* (Wright 1968*a* : 276). Temple (1970 : 27) describes *D.* cf. *indenta* from Meifod which also lacks a dorsal ridge and is similar to the Glyn Ceiriog species in length : width of the valves and in the relative length of the ventral muscle field. However, it appears to be relatively thicker and has more widely divergent lobes, although this may be a result of the smaller mean size of the Meifod specimens (see Wright 1968*a* : 265).

D. cf. *indenta* from the Keisley Limestone is superficially like the species under discussion but the sample is inadequate for a statistical comparison. Therefore, while the Glyn Ceiriog *Dicoelosia* may not be identical to *D. indenta*, it is considered to be closely allied to it. It is interesting to note that the specimens in which the dorsal ridges have not been recognized have been preserved as natural moulds.

The following statistical data have been obtained from the sample:

Maximum length (l) : maximum width (w) of pedicle valves, n = 34; $\bar{l}$(var. l) = 3·78 (1·394) mm; $\bar{w}$(var. w) = 4·24 (2·303) mm; r = 0·713; a(var. a) = 1·285 (0·02535); $\overline{\log_e l}$(var. $\log_e$l) = 1·283 (0·09313); $\overline{\log_e w}$(var. $\log_e$w) = 1·386 (0·1202); r_e = 0·726; α(var. α) = 1·136 (0·01908).

Maximum length (l) : mid-line length (m) of pedicle valves, n = 34; $\bar{l}$(var. l) = 3·78 (1·394) mm; $\bar{m}$(var. m) = 2·6 (0·523) mm; r = 0·865; a(var. a) = 0·613 (0·00295); $\overline{\log_e l}$(var. $\log_e$l) = 1·283 (0·0913); $\overline{\log_e m}$(var. $\log_e$m) = 0·918 (0·07455); r_e = 0·871; α(var. α) = 0·895 (0·00605).

Maximum length (l) : thickness (t) of pedicle valves, n = 24; $\bar{l}$(var. l) = 3·96 (1·619) mm; $\bar{t}$(var. t) = 1·12 (0·116) mm; r = 0·692; a(var. a) = 0·268 (0·0017); $\overline{\log_e l}$(var. $\log_e$l) = 1·328 (0·09804); $\overline{\log_e t}$(var. $\log_e$t) = 0·066 (0·08906); r_e = 0·702; α(var. α) = 0·953 (0·02093).

Maximum valve length (l) : length of ventral muscle scar (s), n = 20; $\bar{l}$(var. l) = 4·03 (1·118) mm; $\bar{s}$(var. s) = 1·05 (0·107) mm; r = 0·713; a(var. a) = 0·309 (0·00261); $\overline{\log_e l}$(var. $\log_e$l) = 1·36 (0·0664); $\overline{\log_e s}$(var. $\log_e$s) = 0·0025 (0·0925); r_e = 0·721; α(var. α) = 1·18 (0·03712).

Maximum length (l) : maximum width (w) of brachial valves, n = 17; $\bar{l}$(var. l) = 2·96 (0·461) mm; $\bar{w}$(var. w) = 4·32 (1·929) mm; r = 0·673; a(var. a) = 2·045 (0·1524); $\overline{\log_e l}$(var. $\log_e$l) = 1·061 (0·051); $\overline{\log_e w}$(var. $\log_e$w) = 1·414 (0·0982); r_e = 0·683; α(var. α) = 1·387 (0·06846).

Maximum length (l) : mid-line (m) of brachial valves, n = 17; $\bar{l}$(var. l) = 2·96 (0·461) mm; $\bar{m}$(var. m) = 1·96 (0·386) mm; r = 0·686; a(var. a) = 0·915 (0·02953); $\overline{\log_e l}$(var. $\log_e$l) = 1·061 (0·051); $\overline{\log_e m}$(var. $\log_e$m) = 0·624 (0·0957); r_e = 0·698; α(var. α) = 1·37 (0·06451).

Width of dorsal sulcus at 2 mm growth stage (s), n = 17; $\bar{s}$(var. s) = 1·53 (0·1747) mm.

Width of ventral sulcus at 2 mm growth stage (s), n = 33; $\bar{s}$(var. s) = 1·12 (0·0632) mm.

Dicoelosia sp.
Figs 192–197

MATERIAL AND HORIZON. Internal and external moulds of 2 brachial valves (BB37371, l = 3·3, w = 5·7; BB37374, l = 1·8, w = 3·3) and 7 pedicle valves (including BB37372, l = 4·9, w = 5·3) from the lower part of the Dolhir Formation, 1–50 m above the Dolhir Limestone. Occurs along with *D.* cf. *indenta.*

DESCRIPTION. Ventri-biconvex shells with moderate invagination of anterior margin. Pedicle valve about nine-tenths as long as wide, with mid-line length almost seven-tenths of maximum valve length; thickness just over one-quarter of maximum valve length. Lobes broad, rounded, diverging at about 65°. Hinge-line just over one-half as wide as shell, cardinal extremities obtuse. Sulcus, originating at umbo, deep, narrow, about 0·9 mm wide at 2 mm growth stage. Interarea slightly curved, apsacline; delthyrium open. Brachial valve three-fifths as long as wide, shallow, with slightly convex lateral profile; posterolateral areas concave. Interarea very short, flat, anacline; notothyrium open. Shallow, gently rounded sulcus originating at umbo fairly broad, about 1·4 mm wide at 2 mm growth stage; contained ribs less strongly developed than those on lobes. Ornament of fine costae and costellae.

Ventral interior with teeth supported by erect, narrowly divergent dental lamellae which define muscle field. This about four-fifths as wide as long and less than one-third as long as valve; diductor scars slightly longer than raised median adductor scar. Dorsal interior with blade-like brachiophores diverging at about 115°; bases slightly divergent on to valve floor. Short cardinal process differentiated into bulbous myophore and short shaft. No evidence of dorsal ridges and details of musculature obscure. Punctae not well seen.

DISCUSSION. This species is characterized by its transverse outline, convex brachial valve, broad, widely divergent lobes, and moderate emargination; the pedicle valve is reminiscent of *Epitomyonia* but the brachial valve is typical of *Dicoelosia.* These attributes of the species place it in the '*D. lata*' group (Wright, 1968*a* : 281) but it differs from *D. inghami* Wright, 1968 by having a convex brachial valve and a narrower ventral sulcus. It resembles *D. lata* Wright, 1964 and *D. simulata* Mitchell, 1977, but until more material becomes available and a statistical analysis of the species can be carried out, its exact affinities cannot be properly assessed.

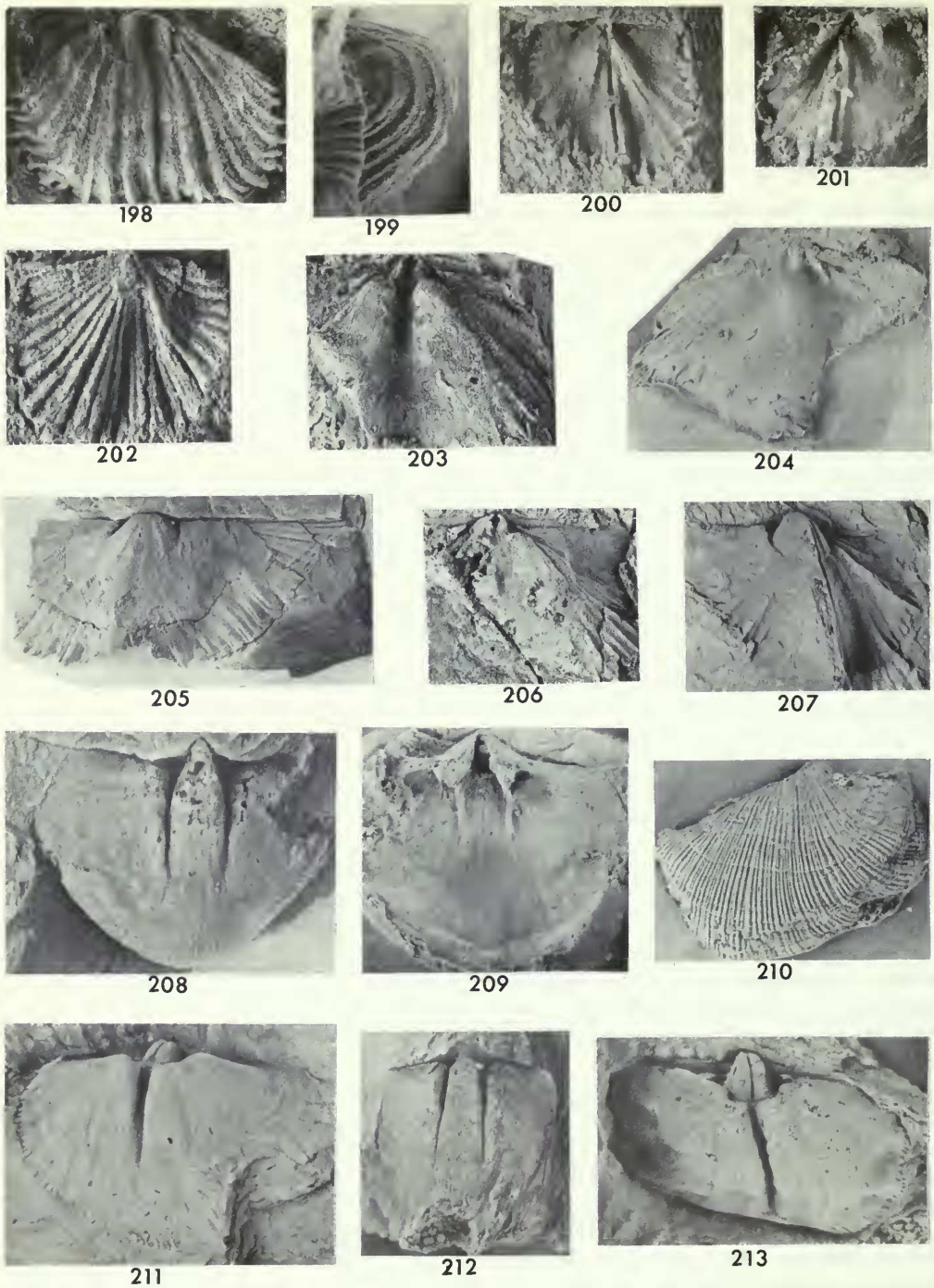
EPITOMYONIA Wright, 1968

Epitomyonia sp.
Figs 198–202

MATERIAL AND HORIZON. An internal mould of a pedicle valve, BB37373 (l = 6·0, w = 8·4) and internal and external moulds of 2 brachial valves (BB37377, l = 4·0, w = 4·3; BB37379, l = 5·0, w = 5·5) from the top of the Cyrn-y-brain Formation, 5 metres below junction with Plas Uchaf Formation.

DESCRIPTION. Concavo-convex shells of subquadrate outline; maximum width about mid-valve; cardinal angles obtuse. Pedicle valve about seven-tenths as long as wide and almost three-fifths as deep as long. Lateral profile strongly convex; anterior profile also strongly convex but with shallow median sulcus which becomes broader anteriorly. Interarea not seen. Brachial valve nine-tenths as long as wide; lateral profile gently convex umbonally but flattening anteriorly to become concave in later growth stages. Flattened posterolateral ears separated from sulcus by relatively narrow convex lobes. Sulcus about 1·3 mm wide at 2 mm growth stage, becoming broader and shallower anteriorly so that invagination of anterior margin is only slight. Interarea very short, flat, anacline. Ornament of subangular costae and branching costellae with about 24 ribs at 3 mm growth stage.

Ventral interior with elongately subquadrate muscle scar bounded laterally by strong ridges which are anterior continuance of dental plates. Median adductor scars raised on thickened ridge which extends as narrow median septum almost to valve margin. Details of teeth and hinge-line obscure. Dorsal interior with cardinal process differentiated into myophore and short, stout



Figs 198–202 *Epitomyonia* sp. Cyrn-y-brain Formation: Figs 198, 199, BB37373, Internal mould of a pedicle valve, ×4·8, loc. C3; Figs 200, 201, BB37377, Internal mould and latex cast of a brachial valve, ×6·0, loc. C3; Fig. 202, BB37379, Latex cast of the exterior of a brachial valve, ×5·8, loc. C3.

Figs 203–207 *Reuschella* sp. Tyn-y-twmpath Member: Figs 203, 204, BB37380, Internal mould and latex cast of a brachial valve, ×2·0, loc. T1; Fig. 205, BB37381, Internal mould of a pedicle valve,

shaft; blade-like brachiophores widely divergent. Median septum rising anterior to cardinal process and extending to shell margin. Details of musculature obscure and no evidence of elevated platform in anterior part of mantle cavity, (Wright, 1968*b* : 130). Punctae well seen over internal surface of valve.

Discussion. The Cyrn-y-brain specimens can apparently be separated from the type species, *E. glypha* Wright 1968, by the deeper pedicle valve, which is three-fifths as deep as long, compared to two-fifths as deep as long for the Swedish species; nor is there the development of an elevated platform in the brachial valve typical of mature specimens of *E. glypha*. It may be that the Cyrn-y-brain specimens are not mature, but they are approximately the same size as Boda Limestone specimens with the platform, although there is a variation in the development of the platform within the Boda sample. The only other record of the genus in Britain is by Temple (1968 : 29) who recovered two pedicle valves from the Lower Llandovery rocks of the Meifod area, but again the sample was too small for statistical comparisons to be made.

Family **HARKNESSELLIDAE** Bancroft, 1928

REUSCHELLA Bancroft, 1928

Reuschella sp.
Figs 203–207

1922 *Orthis* (*Hebertella*) *vespertilio* Sowerby: Wills & Smith: 187.

Material and horizon. Distorted and fragmentary moulds of 3 pedicle (e.g. BB37381, l = 17·0, w = 34·0; BB37383, l = 13·9, w = 18·6) and 8 brachial (e.g. BB37380, BB37382) valves, from the lower and middle parts of the Dolhir Formation, including the Tyn-y-twmpath Member.

Description. Biconvex shells of transversely sub-rectangular outline about three-fifths as long as wide with maximum width anterior to hinge-line; well developed fold and sulcus arising at ventral and dorsal umbones respectively. Cardinal angles obtuse, rounded in large specimens with suggestions of small ears having been developed in younger forms. Pedicle valve unevenly convex, about one-quarter as deep as long, with sharp, angular median fold. Interarea gently curved, apsacline, about one-tenth as long as valve; delthyrium open. Brachial valve moderately convex in lateral profile, becoming flatter anteriorly; anterior profile, indented by strong sulcus, becoming flat posterolaterally; interarea very short, flat, anacline to orthocline; notothyrium open. Ornament of coarse fascicostellate ribbing, with about 28 angular costae and costellae at the 5 mm growth stage on the brachial valve. At 5 mm growth stage one pedicle valve had a density of 3 ribs per 2 mm immediately external to sector 1.

Ventral interior with teeth supported by strong dental lamellae which continue anteriorly for a short distance to form raised lateral edges to the muscle field. Muscle field broadly triangular about four-fifths as long as wide and about one-third as long as valve, with broad adductor scars, occupying about one-half of total scar width, flanked but not enclosed by diductors. Pedicle callist small. Dorsal interior with stout cardinal process, differentiated into swollen, crenulated myophore and short, thick shaft, situated on thickened notothyrial platform. Brachiophores diverging at about 70°–80°, with grooved inner surfaces; sockets elongate. Crural pits small;

×1·7, loc. T1; Dolhir Formation: Fig. 206, BB37382, Internal mould of a brachial valve, ×2·0, loc. D13. Dolhir Limestone Member: Fig. 207, BB37383, Internal mould of a pedicle valve, ×2·0, loc. L3.

Figs 208–213 *Laticrura* cf. *erecta* Wright. Dolhir Formation: Figs 208, 209, BB37391, Internal mould and latex cast of a pedicle valve, ×2·6, loc. D5; Fig. 210, BB37391, Latex cast of the exterior of a pedicle valve, ×2·6, loc. D5; Fig. 211, BB37393, Internal mould of a brachial valve, ×2·8, loc. D4; Fig. 212, BB37388, Internal mould of a pedicle valve, ×3·7, loc. D5; Fig. 213, BB37394, Internal mould of a brachial valve, ×3·3, loc. D4.

notothyrial platform undercut by posterior end of adductor muscle field. Punctae well seen on inner surfaces of valves.

Discussion. The fragmentary and distorted specimens of this sample cannot be assigned with certainty to any of the known species of *Reuschella*. The ribbing is not well enough preserved to study the relative insertion of the costellae so it cannot be used to place this species in either of Bancroft's two groups (1945 : 239). Most of the described species are of Caradoc age except for *R. inexpectata* Temple, 1968 from Keisley and an unnamed species of *Reuschella* from the Portrane Limestone (Wright, 1964). The former differs from the Glyn Ceiriog species in the absence of crural and adductor pits and more widely divergent brachiophores; the latter differs principally in the size and shape of the ventral muscle field, the Portrane form having a narrower, sub-oval scar, and shorter, more widely divergent brachiophores.

Family **LINOPORELLIDAE** Schuchert & Cooper, 1939

LATICRURA Cooper, 1956

Laticrura cf. ***erecta*** Wright, 1964
Figs 208–217

cf. 1964 *Laticrura erecta* Wright: 233; pl. 10, figs 17, 18; pl. 11 figs 16, 18–21.

Material and horizon. Internal and external moulds of 26 brachial and 16 pedicle valves from throughout the Dolhir Formation.

Description. Transversely sub-oval to subcircular ventri-biconvex shells with hinge-line width about two-thirds of maximum valve width, which is situated about mid-valve; cardinal angles obtuse, rounded. Pedicle valve about five-sixths as long as wide, strongly convex in both profiles. Interarea curved, apsacline, almost one-third as long as wide and one-fifth as long as valve; delthyrium narrow, open. Brachial valve four-fifths as long as wide; gently convex in both profiles with anterior profile indented medianly by variably developed shallow sulcus originating close to umbo. Interarea curved, anacline less than one-tenth as long as valve; notothyrium open. Ornamentation of fine hollow costae and costellae, typically with 4 ribs per mm medianly at 5 mm growth stage on brachial valve. Slightly swollen costellae developed on some specimens.

Ventral interior with teeth supported by very narrowly divergent dental plates whose anterior continuance defines elongately rectangular muscle field about one-half as wide as long and over two-fifths as long as valve; broad median adductor scars flanked by pair of narrow diductors. Pedicle callist developed. Dorsal interior with simple ridge-like cardinal process on notothyrial floor which thickens anteriorly and is bounded by high, almost vertical brachiophore plates. Brachiophores broad and 's' shaped in cross-section; sockets defined by fulcral plates. Strong median septum extends in front of notothyrial platform for about seven-tenths of valve length and may be up to 1 mm in height near posterior end. Pair of lanceolate adductor scars, each about one-half as long as valve, on either side of septum; narrower posterior scars about two-thirds as long as anterior ones. Traces of radiating mantle canals seen on floors of both valves.

Dimensions

	length	width
Internal mould of a pedicle valve, BB37388	—	7·6
Internal and external moulds of a brachial valve, BB37390	9·2	14·1
Internal and external moulds of a pedicle valve, BB37391	12·8	—
Internal mould of a brachial valve, BB37392	11·7	17·3
Internal mould of a brachial valve, BB37394	9·2	10·9
Internal mould of a brachial valve, BB37395	7·1	10·0

Discussion. Of the six species previously assigned to *Laticrura*, the forms which most closely resemble the specimens described here are *L. pionodema* Cooper, 1956 and *L. erecta* Wright, 1964. A comparison of length : width percentage of 11 Welsh brachial valves, mean 79·7% (var. 26, 83) with Williams' (1962 : 145) figures for the Scottish and American samples of *L. pionodema*

shows no significant difference between the two forms. A similar test also shows no significant difference between *L. erecta* and the Glyn Ceiriog species.

An important attribute in differentiating between species of *Laticrura* is the density of the ribbing. 3–5 ribs per mm were observed on 1, 7, 2 and 1, 5, 0 brachial valves of *L. erecta* at 5 mm and 7·5 mm growth stages respectively. Of the two dorsal exteriors sufficiently well preserved in the Glyn Ceiriog sample, one has 4 ribs per mm at both 5 mm and 7·5 mm growth stages, while the other has 4 ribs per mm at 5 mm and 3 ribs per mm at 7·5 mm thus showing a closer affinity of the Welsh species for *L. erecta*.

Cooper (1956) also used the development of an apical plate rather than a pedicle callist, and the definition of a dorsal sulcus to distinguish between species. The Glyn Ceiriog pedicle valves develop a pedicle callist and in this respect resemble *L. pionodema*, whereas *L. erecta* has an apical plate. All three forms have a broad shallow sulcus. Williams (1962 : 145) questions the importance of the difference between a pedicle callist and an apical plate as they serve the same function, and he states that sulcus development seems to be very variable within a *Laticrura* population; accordingly these attributes must be treated cautiously when being used as specific characters.

The Glyn Ceiriog form is apparently intermediate between *L. erecta* and *L. pionodema* but in view of the similarity in their ribbing the Welsh species is considered to be closer to the Portrane form. A test comparing the relative length of the dorsal median septum in the Irish and Welsh forms shows that there is no significant difference between them. Williams (1962 : 144) describes the anterior dorsal adductor scars as being narrower than the posterior pair but in the Glyn Ceiriog specimens it is the posterior pair that are narrower.

Data for a bivariate analysis of length of median septum (s) : length of brachial valve (l), n = 12; $\bar{s}$(var. s) = 6·2 (4·39) mm; $\bar{l}$(var. l) = 9·0 (9·16) mm; r = 0·973; a(var. a) = 1·443 (0·00502).

Family **SAUKRODICTYIDAE** Wright, 1964

SAUKRODICTYA Wright, 1964

Saukrodictya hibernica Wright 1964

Figs 218–221

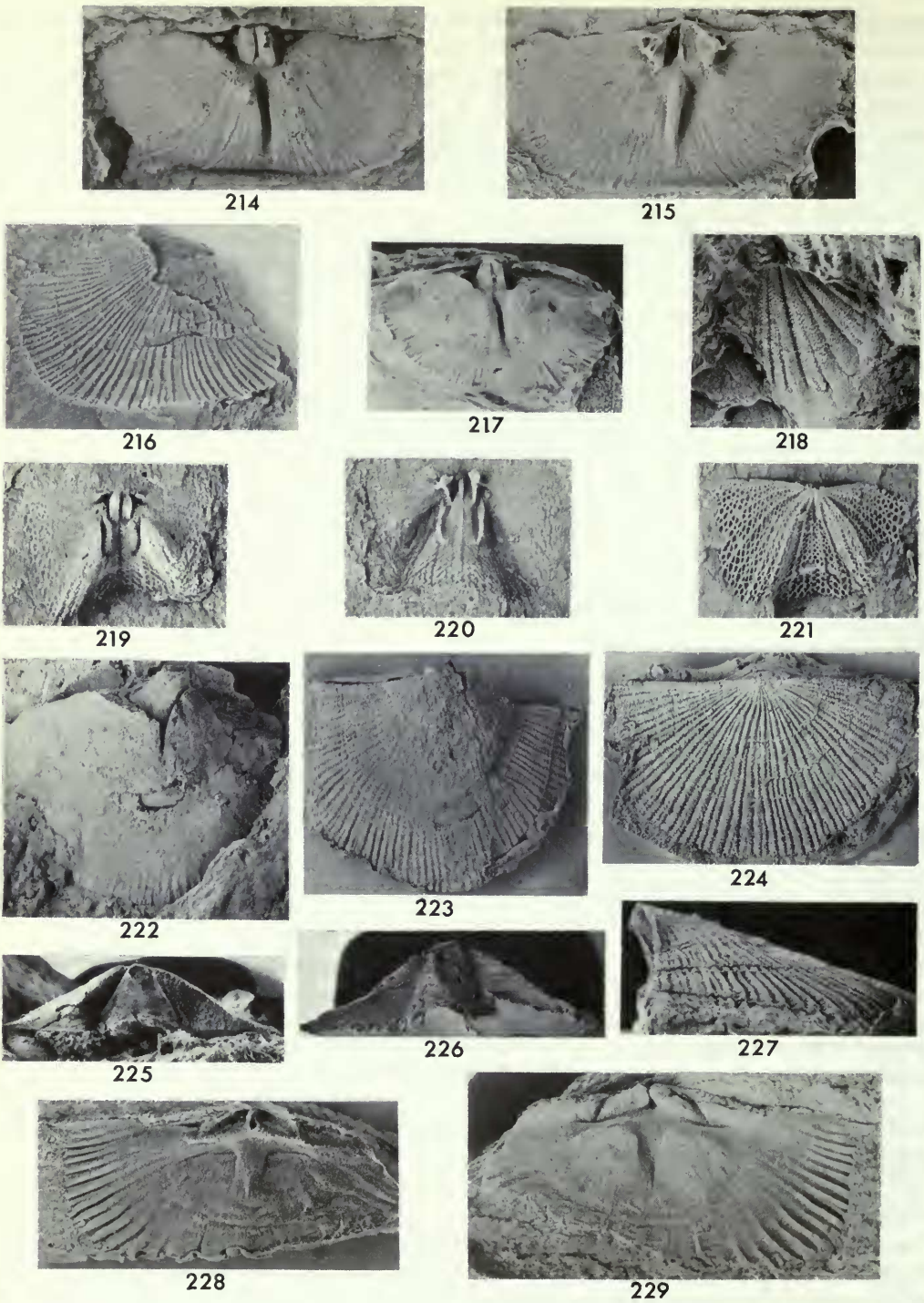
1964 *Saukrodictya hibernica* Wright: 220; pl. 7, figs 21, 23, 24, 26, 28–30.

MATERIAL AND HORIZON. Internal and external moulds of a well preserved brachial valve, BB37397 (length 4·2, width 6·2), from the lower part of the Dolhir Formation, 50 m above the Dolhir Limestone and 2 fragmentary external moulds from 1 m and 16 m above the limestone.

DESCRIPTION. Strongly sulcate, convex brachial valve of transverse outline. Valve about two-thirds as long as wide, maximum width just anterior to hinge-line; cardinal angles slightly obtuse, angular. Deep, rounded sulcus arising close to umbo, about one-half as wide as valve at anterior margin. Interarea very short, anacline approaching catacline; notothyrium open. External ornament of narrow costae and costellae developed within characteristic honeycomb meshwork.

Dorsal interior with short, stout brachiophores; sockets deep, bounded by short fulcral plates. Simple ridge cardinal process situated on notothyrial platform delimited by convergence of brachiophore plates and extending anteriorly into sub-quadrate adductor muscle field. This is sited on slightly raised platform about one-third as long as valve and bisected longitudinally by faint median ridge.

DISCUSSION. When Wright described the type species of *Saukrodictya hibernica* (1964 : 220) the material he used was sparse and fragmentary but the specimen described here largely confirms his impressions; in fact the Welsh specimen agrees so closely with the description of the Irish form that the two must be regarded as being conspecific, even though the sample is too small to compare them statistically. The Welsh *Saukrodictya philipi* (Davidson, 1883) from the lower Tre-Wylan Beds (Ashgill) of Llansantffraid (Cocks, 1978 : 83) requires further evaluation. The author here follows Temple (1970 : 33) in placing this rare genus within the Enteletacea although the Glyn Ceiriog specimen shows no sign of punctae. The small sample from Meifod clearly shows endo-



Figs 214–217 *Laticrura* cf. *erecta* Wright. Dolhir Formation: Figs 214, 215, BB37390, Internal mould and latex cast of a brachial valve, ×2·6, loc. L3; Fig. 216, BB37390, External mould of a brachial valve, ×2·6, loc. L3. Dolhir Formation: Fig. 217, BB37395, Internal mould of a brachial valve, ×3·1, loc. D4.

punctae present on the internal moulds (Temple, 1970 : pl. 7, figs 10, 14, 18) and Wright (1964 : 219) envisaged the possibility of the transfer of the genus from the Orthacea. The Glyn Ceiriog specimen shows the development of short fulcral plates which are not described in the Portrane or Meifod species although in the case of the Irish material this may be a result of preservation.

Suborder **CLITAMBONITIDINA** Öpik, 1934
Superfamily **CLITAMBONITACEA** Winchell & Schuchert, 1893
Family **CLITAMBONITIDAE** Winchell & Schuchert, 1895
Subfamily **CLITAMBONITINAE** Winchell & Schuchert, 1895

VELLAMO Öpik, 1930

Vellamo cf. ***diversa*** (Shaler, 1865)
Figs 222–231

cf. 1865 *Orthisina diversa* Shaler: 67.
1908 *Clitambonites adscendens* Pander; Groom & Lake: 572, 577.
1922 *Clitambonites adscendens* Pander; Wills & Smith: 191.

MATERIAL AND HORIZON. Internal and external moulds of 6 brachial and 9 pedicle valves and 3 pairs of conjoined valves taken from the middle and upper parts of the Dolhir Formation, the Glyn Formation, and from the top of the Cyrn-y-brain Formation.

DESCRIPTION. Ventri-biconvex to plano-convex shells with maximum width usually along hinge-line giving slightly alate appearance. Pedicle valve of pyramidal shape and in some cases distinctly asymmetrical with umbo twisted. Interarea catacline to apsacline with concave to flat, sometimes terraced, profile, over two-fifths as long as wide. Delthyrium about one-third as wide as hinge-line, closed by convex pseudodeltidium perforated by oval foramen.

Brachial valve over three-fifths as long as wide, flat to very gently convex in lateral profile. Convex umbonally and on flanks but concave on posterolateral regions and in broad shallow sulcus which begins at 1 mm growth stage and becomes broader and shallower anteriorly. Interarea very short, about one-tenth of valve length, flat, anacline; notothyrium closed by highly arched chilidium. Ornamentation of even, rounded costae and costellae totalling about 30 and 46 ribs at 5 mm and 10 mm growth stages respectively on pedicle valve. Surface is also ornamented by fine, closely spaced concentric lines but these are never as strong as radial ornament which is only interrupted by growth lines.

Ventral interior with teeth supported by deep, gently curved spondylium simplex. Septum of spondylium extends for almost half of valve length with faint traces of *vascula media* seen, in one specimen to be sub-parallel to it. Dorsal interior with notothyrial cavity divided by short, stout cardinal process; accessory ridges parallel to cardinal process in one specimen; socket ridges widely divergent (about 100°) and about one-sixth as long as wide. Adductor muscle field about one-half as long as wide and just over two-fifths as long as valve, divided longitudinally by rounded median ridge almost two-fifths as wide as long; each half of muscle scar broadly triangular in shape. Thick trunks of *vascula media* are seen to extend from anterolateral corners after crossing anterior half of muscle scars in a few specimens. Anterior and posterior parts of scars are of about equal length.

Figs 218–221 *Saukrodictya hibernica* Wright. Dolhir Formation: Fig. 218, BB37396, Fragment of an external mould, ×4·0, loc. D6; Figs 219, 220, BB37397, Internal mould and latex cast of a brachial valve, ×4·7, loc. D3; Fig. 221, BB37397, Latex cast of the exterior of a brachial valve, ×4·7, loc. D3.

Figs 222–229 *Vellamo* cf. *diversa* (Shaler). Glyn Formation: Figs 222, 225, BB37404, Internal mould of a pedicle valve, ×1·8, ×1·9, loc. G3; Figs 223, 226, 227, BB37404, Latex cast of the exterior of a pedicle valve, ×1·8, ×1·8, ×2·3, loc. G3. Dolhir Formation: Fig. 224, BB37399, Latex cast of the exterior of a brachial valve, ×2·5, loc. D13; Figs 228–9, BB37403, Internal mould and latex cast of a brachial valve, ×4·0, ×3·5, loc. D14.

DIMENSIONS

	length	width
External mould of a brachial valve, BB37399	11·5	18·0
Internal mould of a pedicle valve, BB37400	14·5	24·4
Internal and external moulds of a brachial valve, BB37403 . .	7·5	14·4
Internal and external moulds of a pedicle valve, BB37404 . .	19·6	26·2

DISCUSSION. Some specimens have been tectonically deformed or fragmentary, but the majority, especially those from rottenstone bands, show the major features very well. Deformation may account for some of the asymmetry in the pedicle valves but some twisting of the ventral umbo is well known throughout this genus.

Clitambonites ascendens was recorded from the Dolhir and Glyn Formations by Groom & Lake (1908), and described from further west in the Berwyn Hills by Davidson (1868; 1883) as *Orthisina adscendens*. It was also recorded from the Drummuck Group, Girvan by Reed (1917) and Lamont (1935). However, Öpik, (1930 : 213), stated that the British specimens belonged to the genus *Vellamo* and as *C. adscendens* (Pander) is the type species of *Clitambonites*, the *C. adscendens* of Davidson must be a separate species. Hence the specific characters of this *Vellamo* have not been assessed. Only two other species of the genus have been described from the British Isles, *Clitambonites shallochensis* (Davidson) emend. Reed, which was later placed in synonomy with *V. pyramidalis* (Pahlen) by Öpik (1930 : 213), and *V. sulculata* (Wright) from the Portrane Limestone. Both these differ from the Welsh form in that they are more coarsely ribbed and have a sulcus in the pedicle valve.

The Glyn Ceiriog *Vellamo* is characterized by its apsacline ventral interarea, shallow dorsal sulcus, slightly alate hinge-line and 30 and 46 ribs at 5 mm and 10 mm growth stages respectively. Of the 20 species and 3 subspecies listed by Öpik (1934) the closest to the Welsh form are: *V. verneuili* (Eichwald), *V. leigeri* (Öpik), *V. sauramoi* (Öpik) and *V. wesenbergensis* (Pahlen). The first differs from the Glyn Ceiriog species in having a concave brachial valve, coarser ribbing and a relatively shorter dorsal muscle field in which the posterior scars are always longer and wider than the anterior ones. Also the spondylial septum reaches almost to valve margin. *V. leigeri* has a sulcus in the pedicle valve and a relatively longer dorsal muscle field. *V. sauramoi* is much more coarsely ribbed than the Welsh form and has a longer ventral interarea. *V. wesenbergensis* is very similar to the Glyn Ceiriog species although it does not appear to be alate from Öpik's figures (pl. 10) as is the case with its subspecies, *V. wesenbergensis auriculata*.

Of the American species of *Vellamo*, the one which most closely resembles the Welsh species is *Vellamo diversa*, from the Richmond of Anticosti Island. A small topotypic sample of this species was studied and found to be practically identical to the Glyn Ceiriog form. It was found to have an apsacline ventral interarea, a shallow dorsal sulcus beginning within 1 mm of the umbo, an alate hinge-line, and 30 and 48 ribs respectively at the 5 mm and 10 mm ventral growth stages. The growth ratios of external characters were found to agree closely with those for the Glyn Ceiriog *Vellamo* and any differences were of a minor nature and not statistically significant.

Unfortunately it was not possible to study the interior of the American shells, but in his discussion of *V. wesenbergensis*, Öpik (1934 : 109) points out that one of his specimens (pl. 10, fig. 8) was reminiscent of *V. diversa*. This specimen shows the interior of the brachial valve in which the adductor muscle field is about one-half as long as wide and nearly two-fifths as long as valve. The posterior and anterior parts of the scar are approximately equal in length. Twenhofel (1928) figured the interior of a brachial valve (pl. 23, fig. 11) which shows that the subquadrate anterior adductor scars are slightly larger than the subtriangular posterior pair, although the relative dimensions are similar to Öpik's specimen. However, variation in the muscle field cannot be assessed on the basis of these two figured specimens.

Thus the Welsh, and indeed other British species of *Vellamo* previously described as *Clitambonites adscendens* are closely related to *V. diversa* and *V. wesenbergensis*. This latter was, however, recorded from rocks of the Rakvere (E) stage of Estonia, which is slightly older than the Ashgill horizons from which the British specimens were taken, and the Richmond horizons containing *V. diversa*. Twenhofel (1928 : 200) in his discussion on *C. diversa* said that the nearest European representative was *C. verneuili* and another related species was *C. adscendens*, which

differed in size and shape of the ventral interarea and a convex brachial valve. However, *C. verneuili* is different from *V. diversa* (Shaler) but it is not clear to which genus he referred when he mentioned *C. adscendens*. If he meant the British specimens of *Vellamo* then the differences may have been merely the result of variation within the species, but if he actually meant the type species of *Clitambonites*, then the differences were well founded.

Superfamily **GONAMBONITACEA** Schuchert & Cooper, 1931
Family **KULLERVOIDAE** Öpik, 1934

KULLERVO Öpik, 1934

Kullervo complectens (Wiman) ***albida*** (Reed, 1917)
Figs 232–238

1917 *Clitambonites complectens* (Wiman), var. *albida* Reed: 916, pl. 21, figs 19, 20.
1964 *Kullervo complectens albida* (Reed); Wright; 241, pl. 10, figs 3, 10, 13, 15–20.

Material and horizon. Internal and external moulds of 3 brachial valves (e.g. BB37407, l = 4·3, w = c. 10) and 5 pedicle valves (e.g. BB37405, l = 4·9, w = c. 9; BB37406, l = 4·4; BB37409, l = 8·5) from throughout the Dolhir Formation.

Description. Strongly ventri-biconvex shells with maximum width along hinge-line. Pedicle valve pyramidal with flat to concave posterolateral regions bounded by convex flanks; shallow sulcus, about one-quarter as wide as valve, variably developed. Ventral surface very gently convex in lateral profile; interarea high, curved, apsacline at umbo but becoming catacline near hinge-line, and about one-half as long as wide. Brachial valve alate, with very small umbo, anterior profile gently convex with shallow median sulcus, and flat areas posterolaterally. Length to width ratios of 33% and 42% recorded for two valves. Concentric ridges prominent over whole shell surface and stronger than radial ornamentation in most cases although ribs bounding sulcus show greater prominence in 3 out of 4 pedicle valves. Frequency of concentric ridges per 2 mm of valve length measured anteromedianly from 3 mm growth stage is 3, 5, 5, 6 on four pedicle valves. Concentric ornamentation usually only marking on posterolateral areas of both valves; elsewhere well developed costae and costellae produce a reticulate pattern with concentric ridges. Ventral sulcus delimited on either side by costa much stronger than any other rib in 2 out of 4 specimens; of the remaining specimens one has external costae of similar strength and in the other the sulcus is not seen. Number of ribs in sulcus varies with about 5 in clearly reticulate specimens, but only 2–3 when concentric ridges are dominant. Counts of strong ribs on left flank, external to rib bounding sulcus, show 2–4 ribs on 1, 2, 1 specimens respectively. Total ribs occurring on flank at 3 mm growth stage are 5–7 on 2, 0, 2 valves respectively, these numbers being very much dependent on clear definition of ribs. Dorsal ornamentation similar, with shallow sulcus bounded by strong ribs and a further 2 or 3 external to these.

Ventral interior with spondylium supported by stout median septum; no subsidiary ridges seen. Traces of pinnate vascular markings observed on floor of valve. Dorsal cardinalia consisting of broad, widely divergent socket ridges almost one-third as long as wide; in narrow space between their posterior ends no cardinal process has been observed. Anteromedianly socket ridges united with thick notothyrial platform, passing anteriorly into thick median ridge which is an internal reflection of sulcus. Lanceolate adductor scars impressed on valve floor on either side of median ridge with apices directed posteromedianly.

Discussion. When Öpik erected the genus *Kullervo* he divided the species into four groups on the basis of their external ornament (1934 : 162).
Group 1: is characterized by dominant radial ornament with fine concentric ridges, and a reticulate pattern developed only on the ears, e.g. *K. panderi* Öpik and *K. intacta* Öpik.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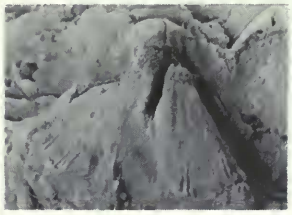
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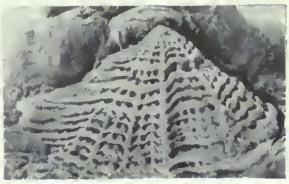
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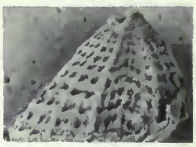
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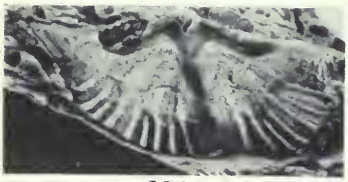
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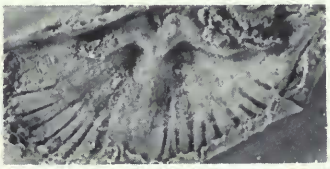
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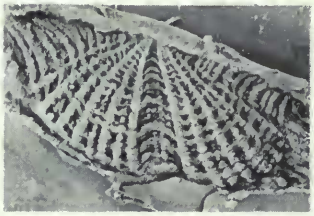
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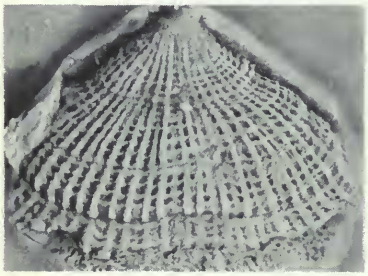
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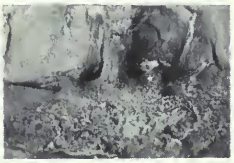
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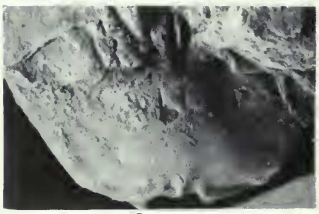
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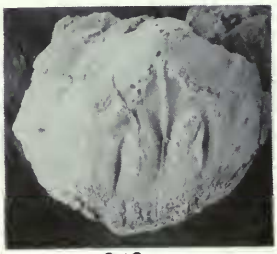
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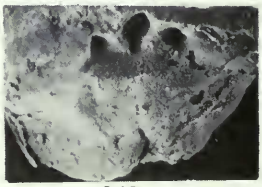
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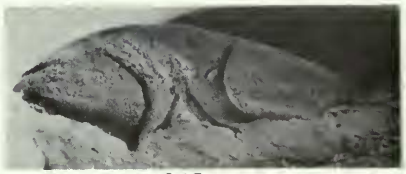
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Figs 230–231 *Vellamo* cf. *diversa* (Shaler). Dolhir Formation: Fig. 230, BB37403, Latex cast of the exterior of a brachial valve, ×4·0, loc. D14; Fig. 231, BB37400, Internal mould of a pedicle valve, ×2·0, loc. D15.

Group 2: with *K. lacunata* Öpik and *K. aluverensis* Öpik, has strong radial ribs in the middle sector but dominant concentric ornament on the ears.
Group 3: including *K. complectens* (Wiman), shows concentric ornamentation as strong as the radial over the whole valve surface.
Group 4: has concentric ornamentation dominant over the whole of the valve, and Öpik placed *K. complectens albida* (Reed) into this group.

The strong concentric ornament of the Glyn Ceiriog species immediately separates it from groups 1 and 2, and the arrangement of the radial ornament with only concentric ornamentation on the ears indicates a close affinity with *K. complectens albida* in group 4. When Reed erected his subspecies (1917 : 916) he stated that the ventral surface was covered with regular, strong, equidistant, thick, raised, rounded concentric lines and that the lateral margins of the sulcus were marked by one fine, strong straight rib, with traces of 2–3 very faint, smaller ribs on the lateral slopes of the valve. Therefore, it differs from *K. complectens* s.s. in having the radial ornamentation scarcely developed so that the reticulate ornament is not apparent; *K. complectens* shows strong reticulation. Of the Glyn Ceiriog specimens, 3 out of 4 are similar to Reed's subspecies while the fourth, a broken valve, shows stronger radial ornament.

Two forms which are similarly ornamented to the Welsh species are *K. pyramidata* Cooper & Kindle, 1936 from the Upper Ordovician of Quebec and *K. ornata* Cooper, 1956 from the Middle Ordovician of Virginia and Alabama. The former differs from the Glyn Ceiriog species in lacking a sulcus on the pedicle valve, and the latter has a concave brachial valve and lacks the alate hinge-line.

Thus the Welsh form has closest affinities with *K. complectens albida* in having the sulcus bounded by a rib stronger than the others and the concentric ornamentation being generally dominant.

Kullervo sp.
Fig. 239

Material and horizon. A single external mould of a pedicle valve, BB37410, from the upper part of the Dolhir Formation. Length 8·1 mm.

Description. Pyramidal pedicle valve with gently convex anterior profile. Ornament of strong concentric ridges equal in strength to radial ornament over whole of valve surface; radial costae of equal strength. Frequency of concentric ridges is 5 per 2 mm measured anteromedianly from 3 mm growth stage.

Brachial valve and interior unknown.

Discussion. This pedicle valve is distinct from *K. complectens albida* in its much stronger radial ornamentation, so that the reticulate pattern is more marked; also it lacks a well defined sulcus. The specimen does not have the posterolateral areas preserved, so further identification cannot be attempted.

Figs 232–238 *Kullervo complectens albida* (Reed). Dolhir Formation: Fig. 232, BB37409, Latex cast of a fragment of the exterior of a pedicle valve, ×4·2, loc. D4; Fig. 233, BB37405, Internal mould of a pedicle valve, ×4·1, loc. D6; Fig. 234, BB37405, Latex cast of the exterior of a pedicle valve, ×4·1, loc. D6; Fig. 235, BB37406, Latex cast of a fragment of the exterior of a pedicle valve, ×3·9, loc. D15; Figs. 236–7, BB37407, Internal mould and latex cast of a brachial valve, ×4·1, loc. D6; Fig. 238, BB37407, Latex cast of the exterior of a brachial valve, ×4·1, loc. D6.

Fig. 239 *Kullervo* sp., Dolhir Formation, BB37410, Latex cast of the exterior of pedicle valve, ×4·0, loc. D6.

Figs 240–245 *Triplesia* cf. *insularis* (Eichwald), Dolhir Formation: Figs 244–5, BB37412, Internal mould of a pedicle valve, ×2·1, ×3·0, loc. D4; Fig. 243, BB37419, Internal mould of a brachial valve, ×2·4, loc. D6; Fig. 241, BB37415, Internal mould of a brachial valve, ×2·8, loc. D15; Fig. 242, BB37417, Internal mould of a brachial valve, ×2·2, loc. D15; Fig. 240, BB37420, Latex cast of cardinalia, ×2·5, loc. D4.

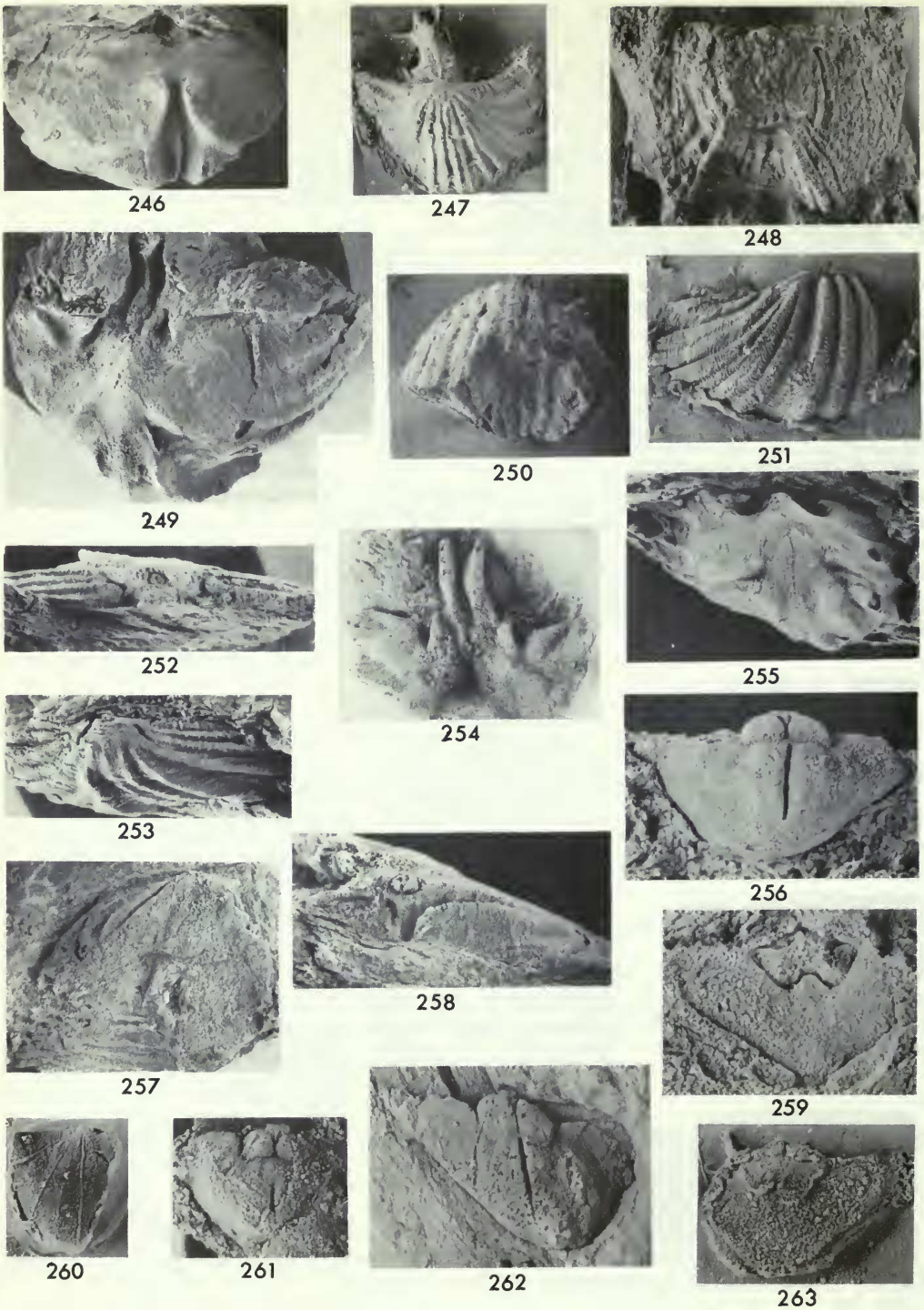

Fig. 246 *Triplesia* cf. *insularis* (Eichwald). Dolhir Formation: BB37414, Internal mould of a brachial valve, ×2·6, loc. D11.

Fig. 248 *Cliftonia* sp. Plas Uchaf Formation: BB37422, Internal mould of a pedicle valve, ×2·7, loc. P1.

Suborder **TRIPLESIIDINA** Moore, 1952
Superfamily **TRIPLECIACEA** Schuchert, 1913
Family **TRIPLECIIDAE** Schuchert, 1913

TRIPLESIA Hall, 1859

Triplesia cf. ***insularis*** (Eichwald, 1842)
Figs 240–246

cf. 1842 *Terebratula insularis* Eichwald: 49, pl. 2, figs 6a–c.
1908 *Triplesia* cf. *insularis* Eichwald; Groom & Lake: 573, 578.
1922 *Triplecia insularis* Eichwald; Wills & Smith: 187, 191.

MATERIAL AND HORIZON. 70 brachial valves, 5 pedicle valves and 2 pairs of conjoined valves from throughout the Dolhir Formation and the Glyn Formation.

DESCRIPTION. Large dorsi-biconvex shells slightly wider than long with maximum width just posterior to mid-valve; cardinal angles rounded. Pedicle valve moderately convex in lateral profile; anterior profile with flat to slightly concave flanks on either side of rounded median sulcus originating about 3·5 mm from umbo; initially this is a shallow depression deepening anteriorly with development of rounded, dorsally projecting tongue. Interarea curved, apsacline, one-fifth as long as wide and about seven-tenths as wide as valve; delthyrium closed by flat pseudodeltidium with narrow median fold developed in all available specimens; apical foramen. Brachial valve strongly convex in both profiles, with low, gently convex median fold originating about 4 mm from umbo. Exterior devoid of ornament except for occasional concentric growth lines. Shell substance thick umbonally but becoming very thin near margins.

Ventral interior with slight development of pedicle passage in 2/6 specimens; teeth supported by thin, divergent dental lamellae. Large, cordate muscle field lightly impressed. Dorsal interior with strong, forked cardinal process whose width is about one-quarter of distance between ends of brachiophores; fork fused into single unit proximally, 'keeled' process of Wright (1971 : 354). Adductor scars and *vascula media* usually visible.

DIMENSIONS

	length	width
Internal mould of a pedicle valve, BB37412	17·5	—
Internal mould of a brachial valve, BB37414	—	16·6
Internal mould of a brachial valve, BB37317	14·6	19·2
Internal mould of a brachial valve, BB37419	c. 10	c. 14

DISCUSSION. The triplesiids have suffered more than any other brachiopods from tectonic distortion; it is probably the result of a combination of their fairly large size and the fact that their shells are quite thin except near the hinge-line. Wright (1964 : 246) points out that specific differentiation in *Triplesia* is based largely on shell shape and style of folding. In the case of the

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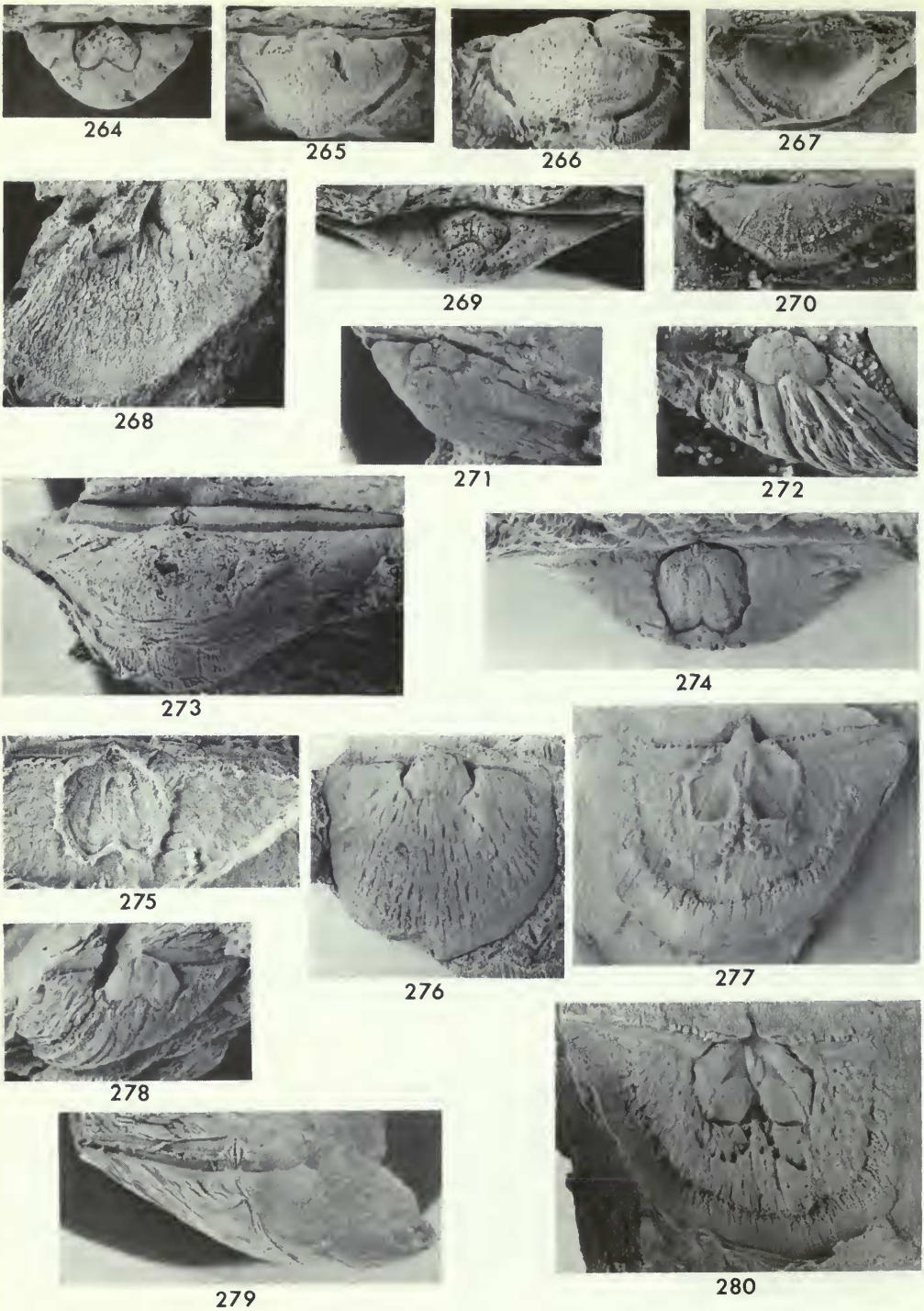
Figs 247, 249–255 *Oxoplecia* cf. *plicata* (Wiman): Dolhir Formation: Figs 249, 254, BB37426, Internal mould of a brachial valve and latex cast of the cardinalia, ×2·3, ×2·9, loc. D6; Fig. 252, BB37431, Internal mould of a pedicle valve, ×2·5, loc. D6; Fig. 255, BB37423, Internal mould of a brachial valve, ×4·4, loc. D1; Fig. 247, BB37432, Latex cast of the exterior of a brachial valve, ×2·8, loc. D4; Fig. 253, BB37430, Internal mould of a pedicle valve, ×3·5, loc. D6; Fig. 251, BB37425, Latex cast of the exterior of a brachial valve, ×2·2, loc. D4. Tyn-y-twmpath Member: Fig. 250, BB37429, Latex cast of the exterior of a pair of conjoined valves, ×2·3, loc. T1.

Figs 257–258 Triplesiid gen. et sp. indet. Dolhir Formation: BB37433, Internal mould of a pedicle valve, ×4·0, ×2·3, loc. D15.

Figs 256, 259–263 *Diambonia* cf. *gibbosa* (Winchell & Schuchert). Glyn Formation: Fig. 256, BB37435, Internal mould of a pedicle valve, ×5·4, loc. G1; Fig. 261, BB37438, Internal mould of a pedicle valve, ×5·4, loc. G1; Figs 259, 263, BB37436, Internal mould and latex cast of a brachial valve, ×6·5, loc. G1. Dolhir Formation: Fig. 262, BB37439, Internal mould of a pedicle valve, ×4·6, loc. D15; Fig. 260, BB37434, Latex cast of the exterior of a pedicle valve, ×4·5, loc. D16.



Figs 264–271, 273 *Leangella* cf. *scissa* (Davidson). Dolhir Formation: Figs 264–267, BB37442, Internal mould and latex cast of a pedicle valve, ×5·0, ×4·9, ×5·1, ×5·0, loc. D5; Fig. 268, BB37447, Fragment of an internal mould of a brachial valve, ×5·0, loc. D15; Fig. 273, BB37444, External mould of a brachial valve, ×4·8, loc. D2; Fig. 270, BB37446, Latex cast of the exterior

Glyn Ceiriog specimens these have been altered by post-depositional distortion. The sulcus on the Welsh shells develops quite late, a sample of 5 valves showing a mean position of origin of 3·52 mm (var. 0·027) from the umbo. This is very similar to that for *T.* cf. *insularis* from the Portrane Limestone where 7 valves show a mean of 3·54 mm (var. 1·23) (Wright, 1964 : 246). Another form which also has a later developing sulcus is *T. uniplicata* (Cooper & Kindle, 1936) but this species has a narrower hinge-line, being only about one-half as wide as the valve, and has a much more delicate cardinal process.

The cardinalia of *Triplesia* are quite distinct from those of the associated *Oxoplecia* and the following data were obtained for a bivariate analysis of cardinal process width (x) : distance between the tips of the brachiophores (y), n = 37; $\bar{x}$(var. x) = 1·08 (0·089) mm; $\bar{y}$(var. y) = 4·60 (0·655) mm; r = 0·411; a(var. a) = 2·72 (0·176). The width of the cardinal process was measured along a line joining the tips of the brachiophores. In a comparison of a's with *T.* cf. *insularis* from the Portrane Limestone, it was found that there was no significant difference in this character between the samples.

CLIFTONIA Foerste, 1909

Cliftonia sp.
Fig. 248

Material and horizon. A single internal mould of a pedicle valve, BB37422, from near the top of the Plas Uchaf Formation on Cyrn-y-brain. Length 9·1 mm, width 12·9 mm.

Description. Pedicle valve about seven-tenths as long as wide and one-quarter as deep as long; maximum width about mid-valve; cardinal angles obtuse. Moderately convex in lateral profile, anterior profile convex with broad, flat-bottomed, median sulcus arising about 2 mm from umbo. Interarea curved, apsacline. External ornament, strongly impressed on valve interior, of broadly spaced concentric lamellae and radial costae and costellae which arise by branching. Dental plates short; other details of interior obscure.

Discussion. This specimen is placed as *Cliftonia* on the basis of its ornament, even though this is only present as an impression on internal mould. Specimens of *Oxoplecia* from the same formation show the strongly impressed radial ornament on the interior but lack the concentric ornament which is too fine to be impressed on the internal mould. The only species of *Cliftonia* previously described from the Ordovician are *C. oxoplecioides* Wright, 1963 from the Chair of Kildare Limestone, and from the Kosov Formation, Bohemia (Marek & Havlíček, 1967), and *C. psittacina* (Wahlenberg, 1820) from the Ashgill of Sweden. The single specimen from Cyrn-y-brain has similarities with both of these species but until further material becomes available it cannot be assigned, with certainty, to either.

OXOPLECIA Wilson, 1913

Oxoplecia cf. *plicata* (Wiman, 1907)
Figs 247, 249–255

cf. 1907 *Triplecia plicata* Wiman: 12; pl. 2, figs 13–17b.
1908 *Triplesia* cf. *spiriferoides* M'Coy; Groom & Lake: 573.
1922 *Orthis* (*Platystrophia*) *spiriferoides* M'Coy; Wills & Smith: 191.

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of a pedicle valve, ×5·1, loc. D4. Dolhir Limestone Member: Fig. 269, BB37445, Internal mould of a pedicle valve, ×4·0, loc. L3. Tyn-y-twmpath Member: Fig. 271, BB37449, Internal mould of a pedicle valve, ×4·0, loc. T1.

Figs 272, 274–280 *Sampo* cf. *ruralis* (Reed). Dolhir Formation: Figs 277, 280, BB69160, Internal mould and latex cast of a brachial valve, ×2·5, loc. D2; Figs 274, 275, BB69162, Internal mould and latex cast of a pedicle valve, ×2·0, ×2·6, loc. D6; Fig. 272, Internal mould of a pedicle valve, ×3·5, loc. D6; Fig. 279, BB69161, External mould of a brachial valve, ×3·5, loc. D6; Fig. 278, BB69157, Internal mould of a pedicle valve, ×2·5, loc. D4. Glyn Formation: Fig. 276, BB69159, Internal mould of a pedicle valve, ×2·3, loc. G3.

Material and horizon. Sixteen brachial and 8 pedicle valves from throughout the Dolhir Formation and from near the top of the Cyrn-y-brain Formation.

Description. Dorsi-biconvex shells of transversely subquadrate outline with maximum width about mid-valve; cardinal angles rounded, obtuse; pronounced dorsal fold and ventral sulcus. Pedicle valve about four-fifths as long as wide and almost one-quarter as deep as long; evenly convex in lateral profile but anterior profile with gently convex flanks separated by broad, flat-bottomed sulcus originating at just over 2 mm from umbo. Interarea curved, apsacline: delthyrium closed by flat pseudodeltidium, with narrow median fold developed in 1 out of 7 specimens; foramen apical. Brachial valve about two-thirds as long as wide and two-fifths as deep as long; strongly convex in lateral profile, maximum convexity near umbo; anterior profile with strongly convex flanks and flat-topped median fold, originating at about 2 mm from umbo. Concentric ornamentation of fine fila, about 7 per mm; radial ornamentation of stout rounded costae and costellae, the latter arising by bifurcation and intercalation. Fold and sulcus initially with 3 and 2 costae respectively; on brachial valve wavelength of ribs at 7·5 mm growth stage is about 1·4 mm, with total of 11–18 ribs developed at 5 mm growth stage. Development of hood not seen.

Ventral interior with pedicle tube developed; teeth strong, supported by receding dental lamellae. Details of muscle scars obscure. Dorsal interior with large, forked cardinal process deeply cleft proximally. Adductor scars and arcuate *vascula media* usually visible.

Dimensions

	length	width
Internal mould of a brachial valve, BB37423	5·7	8·1
Internal mould of a brachial valve, BB37426	15·6	19·7
External mould of conjoined valves, BB37429	—	c. 17
Internal mould of a pedicle valve, BB37431	—	c. 22
External mould of a brachial valve, BB37432	6·7	11·5

Discussion. Most of the specimens have been quite badly distorted so that measurements are of little use in assessing shell shape. The most useful criteria available for specific identification are the nature of the ornament and details of the cardinalia. (Wright 1964 : 248).

The development of 3 initial costae on the dorsal fold of 13 out of 14 Glyn Ceiriog specimens, the other having only 2, distinguishes them from all but a few species of *Oxoplecia*; viz. *O. subborealis* (Davidson, 1883) emend. Williams 1962; *O. platystrophoides* and *O. costata* Cooper 1930; *O. abnormis*, *O. gibbosa* and *O. parva* Cooper 1956; *O. perfecta* Cooper & Kindle 1936, and *O. plicata* Wiman 1907. Of these the last two most closely resemble the Welsh form, although good samples of these are as yet unavailable. In discussing the Portrane Limestone form, Wright (1964 : 248; 1971 : 354; 1972 : 7) regards the deeply grooved proximal end of the cardinal process as being of some importance and states that this is so far only known from *O. plicata*, and *Oxoplecia* sp. from Kildare although forms whose cardinalia have not yet been studied may show similarity. The Glyn Ceiriog specimens differ in small details from the Portrane species, e.g. they have a finer concentric ornament typically with 7 fila per mm compared to 5 per mm on the Irish shells, although this may be a result of preservation. The 'grooved' type of cardinal process associated with the general lack of a median fold on the pseudodeltidium suggests a close similarity with *O. plicata* whereas *Oxoplecia* sp. from Kildare has a fold on the pseudodeltidium.

The following statistical data were obtained:

Origin of dorsal fold (m), n = 10; $\overline{m}$(var. m) = 2·17 (0·16) mm

Origin of ventral sulcus (m), n = 7; $\overline{m}$(var. m) = 2·33 (0·089) mm

Concentric ornamentation of 5–8 fila per mm on 1, 6, 9, 2, specimens respectively.

Radial ornamentation in the ventral sulcus: (*a*) 8 out of 8 specimens show 2 initial costae; (*b*) at the 3 mm growth stage, 2, 3, 4, ribs occur on 8, 0, 0, valves respectively; at 5 mm on 5, 3, 0 valves; and at 10 mm on 5, 2, 1 valves.

Radial ornamentation on dorsal fold: (*a*) 2, 3 initial costae shown by 1, 13 valves respectively; (*b*) at the 3 mm growth stage 3, 4, 5, 6 ribs shown by 12, 1, 1, 0 valves; at 5 mm by 7, 5, 1, 0 valves; and at 10 mm by 3, 6, 1, 1 valves.

Total ribs on brachial valves at the 5 mm growth stage; 11–18 ribs on 1, 3, 2, 1, 1, 3, 1, 1, valves.

Triplesiid, gen. et sp. indet
Figs 257, 258

MATERIAL AND HORIZON. A single pedicle valve, BB37433, preserved as a damaged internal mould from high up in the Dolhir Formation. Length 13·1 mm.

DESCRIPTION. Pedicle valve asymmetrical, about nine-tenths as long as wide and about one-sixth as deep as long, maximum width anterior to hinge-line, cardinal angles obtuse; flatly convex in lateral profile, anterior profile becoming broadly and gently sulcata from about 2 mm anteromedianly from umbo. Interarea curved, apsacline, about one-sixth as long as valve. Ornament not seen.

Ventral interior with small teeth supported by thin, widely divergent dental plates. Muscle scars obscure. Pedicle tube seen in an apical position.

DISCUSSION. Such a poorly preserved specimen cannot be assigned with confidence to any species or genus.

Order **STROPHOMENIDA** Öpik, 1934
Suborder **STROPHOMENIDINA** Öpik, 1934
Superfamily **PLECTAMBONITACEA** Jones, 1928
Family **LEPTELLINIDAE** Ulrich & Cooper, 1936
Subfamily **LEPTESTIININAE** Havlíček, 1961

DIAMBONIA Cooper & Kindle, 1936

Diambonia cf. ***gibbosa*** (Winchell & Schuchert, 1895)
Figs 256, 259–263

cf. 1895 *Plectambonites gibbosa* Winchell & Schuchert: 416, pl. 32, figs 13–17.
1908 *Plectambonites* sp; Groom & Lake: 573, 577 (pars).
cf. 1936 *Diambonia gibbosa* (Winchell & Schuchert); Cooper & Kindle: 356.

MATERIAL AND HORIZON. Internal and external moulds of 11 pedicle valves and internal and external moulds of a single brachial valve; 5 specimens from the upper part of the Dolhir Formation and 7 from the Glyn Formation.

DESCRIPTION. Concavo-convex shells of transversely semi-circular outline with maximum width along hinge-line. Pedicle valve about two-thirds as long as wide and almost two-fifths as deep as long; lateral profile strongly convex but anterior profile flattening out at posterolateral edges. Interarea curved, apsacline; delthyrium wide, open. Brachial valve almost one-half as long as wide, both profiles concave; interarea flat, catacline; notothyrium filled by cardinal process lobes. External ornament segregated into sectors by accentuated costae and costellae; about 5 enlarged costae at umbo of pedicle valve.

Ventral interior with transverse, bilobed muscle field almost four-fifths as long as wide and about one-third as long as valve; small triangular adductor scars on either side of shallow median groove are separated from larger diductors by small, anteriorly convergent ridges. Divergent *vascula media* arise within diductor muscle field and extend from its anterolateral corners; some specimens show traces of other vascular canals with one pair in central position on either side of median septum and another pair in lateral position. Teeth supported by dental plates whose anterior continuance as low ridges defines muscle field. Median septum high, developed in front of muscle field and extending to about two-thirds of valve length. Some specimens show septum as continuance of that bisecting muscle field.

Dorsal interior with elevated, W-shaped muscle platform about one-half as long as wide and three-tenths as long as valve. Subperipheral rim parallel to margin anterolaterally but curving towards margin medianly. Poorly developed second rim seen on one side of single specimen. Widely divergent socket ridges apparently ankylosed to cardinal process but preservation rather poor.

DIMENSIONS

	length	width
External mould of a pedicle valve, BB37434	4·2	—
Internal mould of a pedicle valve, BB37435	4·2	—
Internal mould of a brachial valve, BB37436	3·8	7·8
Internal mould of a pedicle valve, BB37438	c. 4	—
Internal mould of a pedicle valve, BB37439	5·7	c. 9

DISCUSSION. The genus *Diambonia* was separated from the closely related *Leangella* Öpik by Cooper and Kindle (1936 : 356) on the presence of a marked ventral median septum in front of the muscle field on this form. On the evidence of a sample from Pomeroy, containing both septate and non-septate forms, Mitchell (1977 : 78) concludes that the generic status of *Diambonia* and *Leangella* may have to be reconsidered. Non-septate forms have also been found at Glyn Ceiriog but these occur in horizons above and below those containing the septate shells and consequently have been assigned to *Leangella*. There is variation in the strength of the septum among the Glyn Ceiriog *Diambonia*, but this is probably a result of preservation, and so *Leangella* and *Diambonia* are considered as separate here.

The genus is not common at Glyn Ceiriog, but the reasonably well preserved specimens recovered are distinct from *D.* cf. *discuneata* (Lamont, 1935), the only other Ashgill form for which statistical data are available (Mitchell, 1977 : 78). 10 Glyn Ceiriog pedicle valves have a mean *length of muscle field* : *length of valve* ratio of 29% (var. 12·56); 9 Pomeroy valves have 17·8% (var. 15·94) for the same statistic. A 't' test shows a significant difference between the two ($P < 0{\cdot}001$). A similar difference was observed in the relative length of the median septum which in 9 Glyn Ceiriog valves extended for 66·0% (var. 100·28) of valve length and 8 Pomeroy valves for 43·0% (var. 65·71) of valve length; a 't' test showed a significant difference ($0{\cdot}01 > P > 0{\cdot}002$). Of the two Ashgill species recorded by Cooper & Kindle (1936 : 356), *D. septata* (Cooper, 1930) and *D. gibbosa* (Winchell & Schuchert, 1895), the Glyn Ceiriog form is closer to the latter, which has a large ventral muscle field and a long median septum. However, until more data becomes available for these and other species the affinities of the Welsh form cannot be properly ascertained.

LEANGELLA Öpik, 1933

Leangella cf. *scissa* (Davidson, 1871)

Figs 264–271, 273

cf. 1871 *Leptaena scissa* Davidson: 325, pl. 47, figs 22–23 (non 25, ?21, ?24).
1908 *Leptella* (?) *Llandeiloensis*, Davidson; Groom & Lake: 577, 578 (pars).
1922 *Plectambonites scissa* (Salter); Wills & Smith: 187.
1928 *Leptelloidea scissa* (Davidson), pars; O. T. Jones: 481.

MATERIAL AND HORIZON. Internal and external moulds of 10 pedicle and 5 brachial valves mostly from the lower part of the Dolhir Formation.

DESCRIPTION. Strongly concavo-convex shells of transversely semi-circular outline with maximum width along hinge-line. Pedicle valve about three-fifths as long as wide and almost one-half as deep as long; lateral profile evenly convex but anterior profile flattening out posterolaterally. Interarea curved, apsacline, less than one-tenth as long as wide and about one-tenth as long as valve. Small, apical pseudodeltidium developed. Brachial valve deeply concave with catacline to hypercline interarea; chilidial plates well developed but not closing notothyrium. Ornamentation unequally parvicostellate with four or five widely spaced, accentuated costellae on pedicle valve and irregular rugae on brachial valve of some specimens.

Ventral interior with bilobate muscle field nearly three-quarters as long as wide and less than one-third as long as valve. Teeth small, supported by widely divergent dental lamellae passing anteriorly into low ridges bounding muscle field. Lanceolate adductor scars situated posteromedianly and almost enclosed by diductor scars. Sub-parallel to slightly divergent *vascula media* extend anteriolaterally from corners of diductor scars. Two specimens show faint ridges which

may mark traces of another outer pair of vascular canals (?*vascula dentalia*) (Fig. 271). One specimen which has slight plication of anterior margin, shows sub-peripheral rim developed. This rim is absent from anteromedian portion of valve, over plication, and the flat area outside rim shows tracks of four vascular canals, two on either side of plication, *vascula media* in median position with (?) *vascula dentalia* in posterolateral position (Figs 264–267).

Dorsal interior with strong trilobed cardinal process differentiated into high median ridge flanked by lower lateral lobes, almost filling notothyrial cavity. Muscle field with elevated anterior margin which has median indentation from which broad median ridge extends posteriorly. Row of enlarged tubercles developed anterior to muscle field and parallel to its anterior edge. Floor of valve covered with elongate tubercles.

DIMENSIONS

	length	width
Internal mould of a pedicle valve, BB37442	3·0	6·3
External mould of a brachial valve, BB37444	4·8	c. 11
Internal mould of a pedicle valve, BB37445	6·2	11·3
External mould of a pedicle valve,BB37446	2·6	7·1

DISCUSSION. The genus *Leangella* may be confused with *Leptestiina* (Havlíček, 1952), the main difference between the two being the development of a sub-peripheral rim in the brachial valve of the former (Havlíček, 1967 : 29). The Glyn Ceiriog sample is made up largely of internal moulds of pedicle valves and at least one of these may prove to be *Leptestiina*. The only brachial valve interior found was broken and the margin of the shell was missing so it could belong to either genus, or even to *Diambonia*, although these specimens have been identified as *Leangella* because of the size and strength of the ventral muscle field. The genus is not common at Glyn Ceiriog but when *Diambonia* is found in the upper Dolhir Formation and Glyn Formation then *Leangella* is less common and after the disappearance of *Diambonia* at the end of the Ordovician, *Leangella* reappears in the Lower Llandovery Fron Frys Formation.

The only exclusively Ordovician species of *Leangella* so far recorded are *L. hamari* (Spjeldnaes, 1957) and *L. cylindrica* (Reed, 1917). The former differs from the Glyn Ceiriog shells in having a smaller ventral muscle field, while the latter differs in its much more alate outline. *L. scissa* is recorded from uppermost Ordovician and Llandovery beds and the Glyn Ceiriog specimens appear very similar to it, although the sample is too small for a reliable statistical comparison.

SAMPO Öpik, 1933

Sampo cf. *ruralis* (Reed, 1917)
Figs 272, 274–280

?1908 *Leptella* (?) *Llandeiloensis* (Davidson); Groom & Lake: 577 (pars).
cf. 1917 *Plectambonites ruralis*; Reed: 879, pl. xiv, figs 25–33.
cf. 1928 *Leptelloidea ruralis* Reed; O. T. Jones: 492.

MATERIAL AND HORIZON. Internal and external moulds of 15 pedicle and 4 brachial valves from the Dolhir Formation and Glyn Formation. Most specimens have been tectonically distorted so that few measurements are of use for statistical analysis.

DESCRIPTION. Strongly concavo-convex shells of transversely semi-circular outline with maximum width along hinge-line. Pedicle valve almost three-quarters as long as wide and three-tenths as deep as long; lateral profile evenly convex; anterior profile with convex median region and slightly concave flanks. Interarea curved, anacline, less than one-tenth as long as wide and less than one-tenth as long as valve; delthyrium open except for small apical pseudodeltidium. Brachial valve deeply concave and over one-half as long as wide; interarea flat, hypercline. Ornamentation unequally parvicostellate with about 10–12 widely spaced accentuated costellae at 5 mm growth stage separated by 8–12 very fine ribs.

Ventral interior with up to ten denticles developed along hinge-line on either side of delthyrium; teeth small; widely divergent dental plates seen as part of strong ridge bounding transverse bilobed muscle field, which is over four-fifths as long as wide and three-tenths as long as valve.

Elongate, oval, medianly situated adductor scars enclosed by lobate diductor scars. Vascular markings prominent over whole inner surface of valve. Dorsal interior with strong cardinal process differentiated into high median crest bounded by lower lateral ridges and almost filling notothyrial cavity. Blade-like socket ridges confluent with rim defining muscle field. These ridges meet along elevated anterior edge of muscle field to form median cusp, from which a median ridge runs posteriorly becoming lower until it merges with triangular thickened area immediately in front of cardinal process. This thickened area has two small median grooves which merge anteriorly, and from its antero-lateral angles run two *vascula myaria* which divide anterior and posterior adductor scars on either side of median ridge. Secondary, less pronounced platform developed in front of muscle field, edges defined by two rows of elongate, coarse pustules, originating from below median cusp and diverging from there in two arcs. These pustules probably supported the lophophore. Finer pustules ornament inner surface of valve outside platforms especially along crest of sub-peripheral thickening, which is dissected by radiating vascular canals (Fig. 9).

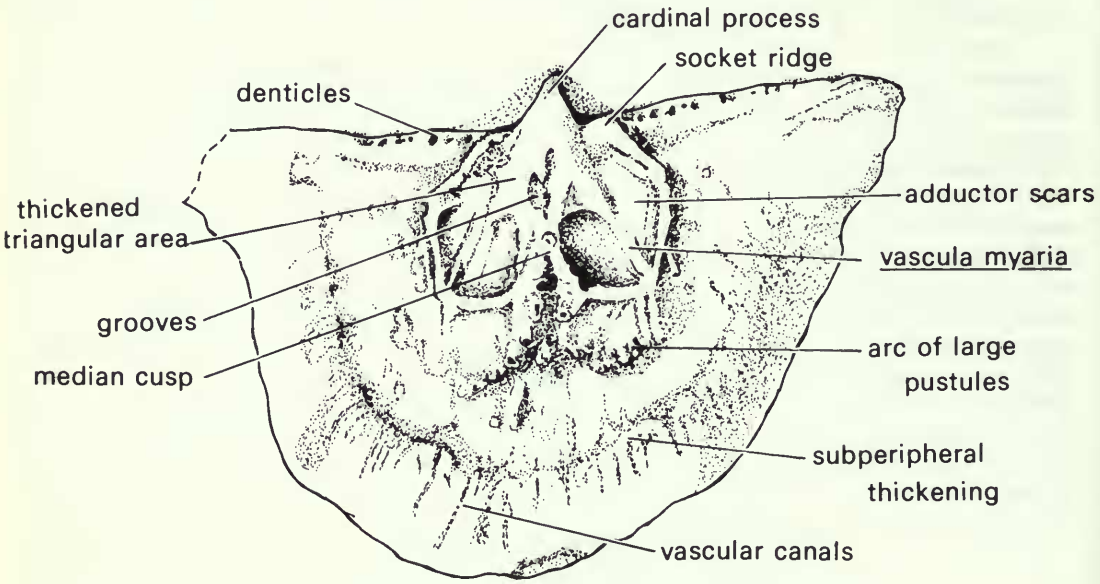


Fig. 9 Diagrammatic view of the dorsal interior of *Sampo* cf. *ruralis*.

DIMENSIONS

	length	width
Internal mould of a pedicle valve, BB69159	14·4	15·6
Internal mould of a brachial valve, BB69160	10·3	18·7
Internal mould of a pedicle valve, BB69162	—	27·5

DISCUSSION. *Sampo ruralis* (Reed, 1917) is a common species in the Ashgill rocks of the British Isles and the Glyn Ceiriog population is very like that from the Portrane Limestone (Wright, 1963 Ms) especially in the dimensions of the ventral muscle field, which in both populations is about four-fifths as long as wide and about one-third as long as valve. However, due to the deformation of the specimens, a statistical comparison of the two samples could only be very tentative.

A comparison of the external ornament with that on a small sample from Girvan shows a close similarity between the Glyn Ceiriog and Girvan species; the Scottish shells have 10–12 accentuated ribs at the 5 mm growth stage with 8–16 fine ribs between them. Thus the Welsh shells are considered to be very closely related to *S. ruralis* although better preserved material is required before statistical comparisons can be made.

Family **SOWERBYELLIDAE** Öpik, 1930
Subfamily **SOWERBYELLINAE** Öpik, 1930
SOWERBYELLA Jones, 1928

Sowerbyella cf. *sladensis* Jones, 1928
Figs 281–289, 292

1908 *Plectambonites sericea* (Sowerby); Groom & Lake: 573, 577.
1922 *Plectambonites sericea* (Sowerby); Wills & Smith: 191.
cf. 1928 *Sowerbyella sladensis* Jones: 421, pl. 21, figs 14–17.
1935 *Sowerbyella sladensis* Jones; Smith: 189, 198.

MATERIAL AND HORIZON. *Sowerbyella* is very common at Glyn Ceiriog with internal and external moulds of 54 brachial valves and 76 pedicle valves being recovered from throughout the Dolhir Formation and 26 brachial and 29 pedicle valves from the Glyn Formation. It is most common at the top of the Dolhir Formation and also quite common in beds of the same age on Mynydd Cricor (15 brachial and 5 pedicle valves) but proportionately less common in these beds in Cyrn-y-brain (6 brachial and 5 pedicle valves).

DESCRIPTION. Concavo-convex shells of transversely subquadrate outline with maximum width at hinge-line or just anterior to it; anterior commissure recti-marginate. Pedicle valve almost three-fifths as long as wide and just over one-quarter as deep as long; cardinal angles normally rectangular to slightly rounded but one small specimen has acute angles; lateral profile with maximum convexity just anterior to umbo; anterior profile moderately and evenly convex. Interarea gently curved, apsacline; delthyrium with small, convex pseudodeltidium.

Brachial valve gently concave in both profiles; anterior profile flattening towards cardinal angles. Interarea very short, flat, catacline; notothyrium partially closed by chilidial plates and almost filled by cardinal process lobe.

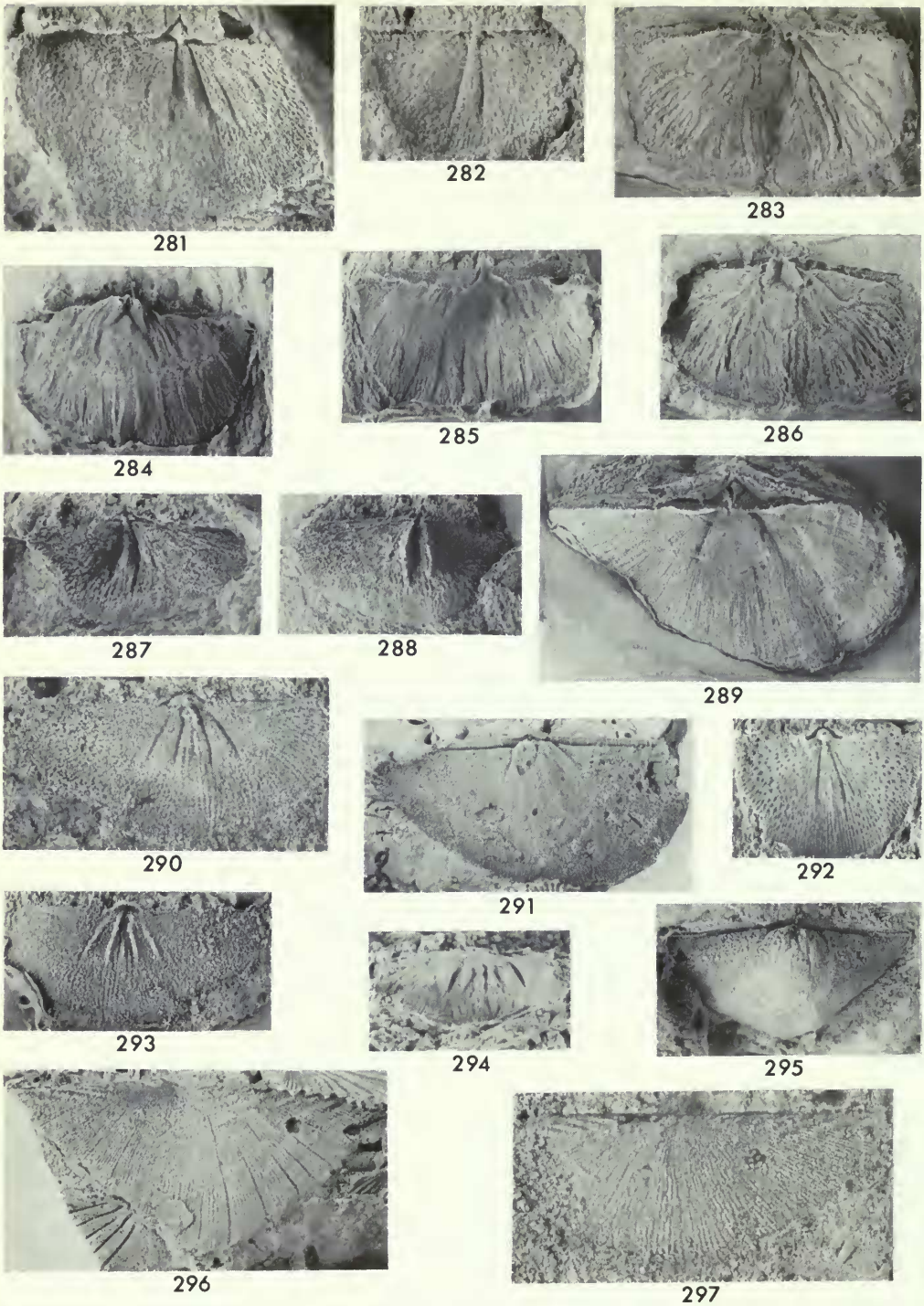
Ornament of fine costellae with density of 7–10 ribs per mm anteromedianly at 5 mm growth stage, segregated into narrow sectors by stronger ribs, with 4–7 ribs between them.

Ventral interior with bilobed diductor muscle scars about two-thirds as long as wide and over two-fifths as long as valve. Small posteromedianly situated adductor scars divided by short septum which extends anteriorly for less than one-fifth of valve length before bifurcating; deeply impressed *vascula media* with lemniscate pattern; teeth small, dental plates obsolescent in adult shells. Dorsal interior with socket ridges almost parallel to hinge-line and pair of narrowly divergent sub-median septa extending anteriorly for three-fifths of valve length. Slightly elevated adductor muscle scars about three-quarters as long as wide and almost two-thirds as long as valve. In some specimens thickened ridges bearing *vascula myaria* are seen to diagonally bisect the muscle scars. In larger specimens these ridges may be accentuated to become almost as strong as sub-median septa. Floors of both valves outside muscle fields covered with coarse pustules which may be ends of taleolae.

DIMENSIONS

	length	width
External mould of a brachial valve, BB69168	c. 10	c. 20
Internal mould of a pedicle valve, BB69170	8·5	13·7
Internal mould of a brachial valve, BB69171	3·5	4·8
Internal mould of a brachial valve, BB69172	4·8	7·9
Internal mould of a pedicle valve, BB69173	9·2	16·3
Internal mould of a brachial valve, BB69174	7·4	10·3
Internal mould of a brachial valve, BB69175	6·2	12·5

DISCUSSION. *Sowerbyella* from Glyn Ceiriog compares closely with *S. sladensis* Jones 1928 and *S. thraivensis* (Reed, 1917): these are distinguished from one another by the smaller size, acute cardinal angles and finer ornament of the latter according to Jones (1928 : 425). He records both forms from the Ceiriog area but only one small specimen has been recovered with acute cardinal angles, and growth lines on some large specimens show that they had acute angles when younger



Figs 281–289, 292 *Sowerbyella* cf. *sladensis* Jones. Cyrn-y-brain Formation: Figs 283, 286, BB69173, Internal mould and latex cast of a pedicle valve, ×2·6, ×2·8, loc. M2; Figs 284–5, BB69170, Internal mould and latex cast of a pedicle valve, ×2·6, ×2·6, loc. M2; Fig. 289, BB69168, Latex cast of the exterior of a brachial valve, ×2·8, loc. M2; Figs 287–8, BB69175, Internal mould and latex cast of a brachial valve, ×3·0, loc. C2. Glyn Formation: Fig. 281, BB69174, Internal mould

but which become more rectangular during growth and more rounded as the shells grew larger. A rib density of 7–10 ribs per mm was observed anteromedianly at the 5 mm growth stage in 4, 4, 3, 4 Glyn Ceiriog shells respectively. This compares with the rib density of *S. sladensis* which Jones (1928 : 421) gives as 7 per mm whereas the figures for *S. thraivensis* from the Killey Bridge Formation, Pomeroy are 10–13 ribs per mm (Mitchell, 1977 : 81). From the evidence available the Glyn Ceiriog specimens are considered to be closely related to *S. sladensis*, although no figures are available from Jones' material for a statistical comparison.

EOPLECTODONTA Kozlowski, 1929

Eoplectodonta sp.

Figs 290, 291, 293, 295–297

?1908 *Plectambonites* sp.; Groom & Lake: 573, 577 (pars).
1922 *Plectambonites sericea*, var. *rhombica* (?); (M'Coy); Wills & Smith: 191.

Material and horizon. Internal and external moulds of 4 pedicle valves, e.g. BB69183, l = 10·5, w = 20·0; BB69184, l = 6·6, w = 12·2, and 6 brachial valves (e.g. BB69185, l = 6·2, w = 13·4) from the Glyn Formation, and 1 pedicle valve from the top of the Cyrn-y-brain Formation.

Description. Concavo-convex shells of transversely semi-circular outline, about one-half as long as wide; maximum width along hinge line. Pedicle valve convex in both profiles, about one-quarter as deep as long. Interarea short, gently curved, apsacline; small pseudodeltidium partially covering delthyrium. Brachial valve concave in both profiles; interarea very short, catacline. Ornament of fine parvicostellae with density of 10–13 per 2 mm anteromedianly 5 mm from ventral umbo, often segregated into sectors by thickened ribs with about 7 others between them; 6–8 posterolateral rugae occur within 3 mm of umbo, subtending an angle of between 12°–29° with posterior margin and extending anteromedianly through a sector of about 13°.

Ventral interior with up to 8 denticles developed in 2 mm on either side of umbo (only seen in 1 specimen). Bilobed muscle field about one-half as long as wide and three-tenths as long as valve; posteromedianly situated adductor scars separated by short septum which extends anteriorly for one-seventh of valve length. Thick *vascula media* extend from anterior edge of muscle field. Dorsal interior with cardinal process fused laterally with socket ridges. Median septum arises later than submedian pair, within 2 mm of umbo; straight submedian septa diverge anteriorly at about 26° and extend for over one-half of valve length. Adductor muscle scars not well defined but each is divided by thin septum which subtends an angle of about 45° with the other.

Discussion. Ashgill *Eoplectodonta* are poorly known when compared to Caradoc and Silurian forms. These few specimens from Glyn Ceiriog bear some resemblance in dimensions to *E. rhombica* (M'Coy, 1852) but appear to have a slightly coarser ornament, although the significance of this cannot be tested on such a small sample.

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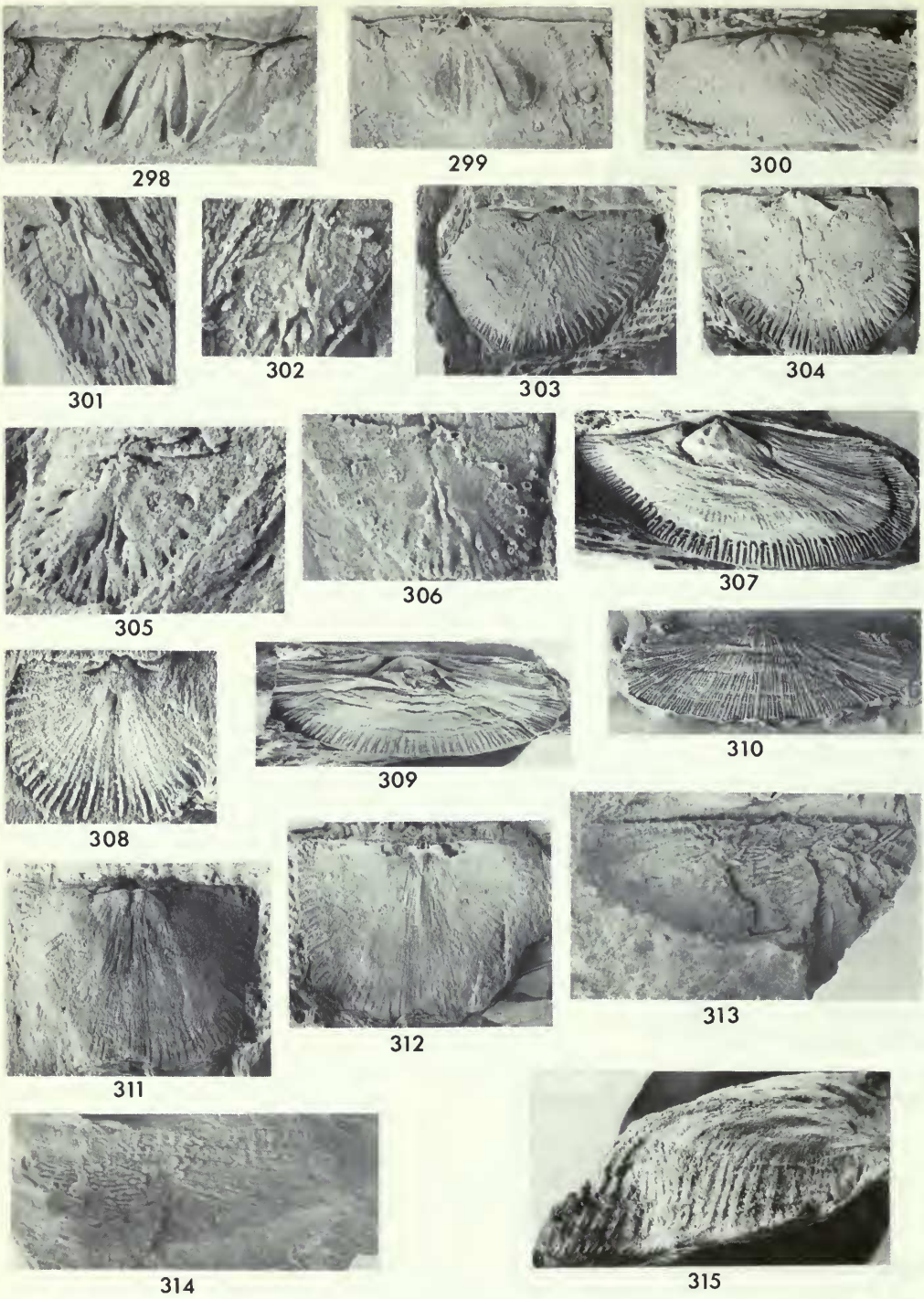
of a brachial valve, ×4·0, loc. G3. Dolhir Formation: Fig. 282, BB69172, Internal mould of a brachial valve, ×4·0, loc. D14; Fig. 292, BB69171, Internal mould of a brachial valve, ×5·4, loc. D14.

Figs 290–291, 293, 295–297 *Eoplectodonta* sp. Glyn Formation: Fig. 297, BB69185, External mould of a brachial valve, ×4·3, loc. G2; Figs 290, 293, BB69185, Internal mould and latex cast of a brachial valve, ×3·8, ×2·9, loc. G2; Fig. 296, BB69183, External mould of a pedicle valve, ×3·2, loc. G2; Fig. 291, BB69183, Internal mould of a pedicle valve, ×3·2, loc. G2. Cyrn-y-brain Formation: Fig. 295, BB69184, Internal mould of a pedicle valve, ×3·0, loc. C2.

Fig. 294 *Kozlowskites* sp. Dolhir Formation: BB69198, Internal mould of a brachial valve, ×6·0, loc. D6.



Figs 298–299 ?*Kozlowskites* sp. Dolhir Formation: BB69197, Internal mould and latex cast of a brachial valve, ×4·4, loc. D5.

Figs 300–302, 305–306 *Chonetoidea* cf. *papillosa* (Reed). Dolhir Formation: Fig. 300, BB69199, Internal mould of a pedicle valve, ×6·0, loc. D4; Figs 301–2, BB69200, Internal mould and latex

KOZLOWSKITES Havlíček, 1952

?*Kozlowskites* sp.
Figs 294, 298, 299

MATERIAL AND HORIZON. Internal moulds of two brachial valves, BB69197–8, from the lower part of the Dolhir Formation 50 m above the Dolhir Limestone. BB69198 length 1·9, width 4·5.

DESCRIPTION. Pedicle valve unknown. Brachial valve concave in both profiles, transversely semi-circular in outline; maximum width along hinge-line. Interarea very short, flat, hypercline; notothyrium filled by cardinal process lobes and chilidial plates. Ornament not seen.

Dorsal interior with cardinal process fused laterally to socket ridges; slender accessory sockets parallel to hinge-line developed about halfway between umbo and cardinal extremities. Smooth, suboval adductor scars raised on thickened platform, about three-fifths as long as wide and about two-thirds as long as valve; each scar divided by strong septum which together subtend an angle of about 45° posteriorly. Thin median septum extends for about one-half of valve length. One specimen (BB69198) shows small papillae developed between medium septum and each half of muscle field.

DISCUSSION. These two incomplete specimens are tentatively included in *Kozlowskites* on the basis of the development of accessory sockets, although no denticles are seen: this may be the result of poor preservation. They are also similar to *Anisopleurella*. No pedicle valves can be assigned with certainty to the genus but several small, strongly concavo-convex, indeterminate plectambonitaceans may prove to be associated with these brachial valves.

Subfamily **AEGEROMENINAE** Havlíček, 1961

CHONETOIDEA Jones, 1928

Chonetoidea cf. *papillosa* (Reed, 1905)
Figs 300–302, 305, 306

cf. 1905 *Plectambonites papillosa* Reed: 451, pl. 23, figs 13–15.
1922 *Plectambonites papillosa* Reed; Wills & Smith: 191.
cf. 1928 *Chonetoidea papillosa* (Reed); Jones: 498, pl. 25, figs 20–24.

MATERIAL AND HORIZON. Internal moulds of 3 pedicle and 2 brachial valves from the lower part of the Dolhir Formation, one specimen from the Tyn-y-twmpath Member, the others from 25 m above this horizon.

DESCRIPTION. Concavo-convex shells of semi-circular to subelliptical outline; maximum width along hinge-line; cardinal angles acute to rectangular. Pedicle valve over one-half as long as wide and almost three-tenths as deep as long; lateral profile with maximum convexity near umbo, anterior profile strongly convex medianly but less so laterally. Interarea short, flat, apsacline; delthyrium partially closed by small convex pseudodeltidium. Brachial valve over three-fifths

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cast of a brachial valve, ×10·0, loc. D4. Tyn-y-twmpath Member: Figs 305–6, BB69201, Internal mould and latex cast of a brachial valve, ×10·0, loc. T1.

Figs 303–304, 307–312 *Strophomena ceiriogensis* sp. nov. Dolhir Formation: Figs 303–4, BB69204, Internal mould and latex cast of a brachial valve, ×1·1, loc. D6; Fig. 307, Holotype, BB69202, Internal mould of a pedicle valve, ×1·4, loc. D6; Figs 311–12, BB69203, Internal mould and latex cast of a brachial valve, ×1·2, loc. D6; Fig. 309, BB69206, Internal mould of a pedicle valve, ×1·9, loc. D6; Fig. 310, BB69206, Latex cast of the exterior of a pedicle valve, ×1·8, loc. D6. Tyn-y-twmpath Member: Fig. 308, BB69207, Internal mould of a brachial valve, ×4·9, loc. T1.

Figs 313–314 *Gunnarella* sp. Dolhir Formation: Fig. 313, BB69209, Internal mould of a brachial valve, ×1·6, loc. D3; Fig. 314, BB69209, External mould of a brachial valve, ×2·2, loc. D3.

Fig. 315 ?*Luhaia* sp. Dolhir Formation: BB69210, Internal mould of a brachial valve, ×1·5, loc. D15.

as long as wide, shallowly concave in both profiles. Interarea very short, flat, hypercline. Ornament not seen.

Ventral interior with bilobed muscle field about two-thirds as long as wide and one-third as long as valve; posteromedianly situated adductor scars separated by short septum, one-fifth as long as valve, which bifurcates anteriorly to bound inner edges of diductors. Inner surface of valve outside muscle field covered by radial rows of pustules which occupy interspaces between impressed ribs. Dorsal interior with cardinalia consisting of narrow socket ridges lying almost parallel to hinge-line, fused medianly with cardinal process. Adductor muscle field about four-fifths as long as wide and about one-half as long as valve, defined by faint ridges. Anterior to muscle field a pair of arcs, of 8 septules each, extend from either side of one median and two submedian septa. Both specimens show the beginnings of a second arc anterior to the first.

DIMENSIONS

	length	width
Internal mould of a pedicle valve, BB69199	3·0	6·5
Internal mould of a brachial valve, BB69200	2·4	3·2
Internal mould of a brachial valve, BB69201	2·3	3·8

DISCUSSION. These specimens are placed in *Chonetoidea* because of their regularly arranged septules and developed in more than one arc. In known *Sericoidea*, the arrangement of septules in the brachial valve is not as well developed as in this species of *Chonetoidea*. Only *C. radiatula* (Barrande) and *C. papillosa* (Reed) are known to develop extra arcs of septules and the present specimens could equally be assigned to either species. Havlíček (1967 : 49) noted the close similarity between these two and Cocks (1970 : 194) in his discussion on *C. papillosa* states, 'Since they are contemporary, and do not appear to differ greatly from each other in material detail, it is possible that *C. papillosa*, *C. radiatula* and *C. tenerima* (Havlíček) might in future be synomymised'. However, Havlíček (1967 : 49) regarded the last to be fairly different because of its reduced number of septules, despite its occurrence in the same formation as *C. radiatula*.

Superfamily **STROPHOMENACEA** King, 1846
Family **STROPHOMENIDAE** King, 1846
Subfamily **STROPHOMENINAE** King, 1946
STROPHOMENA Rafinesque, 1825

Strophomena ceiriogensis sp. nov.
Figs 303, 304, 307–312

?1908 *Rafinesquina expansa* Sowerby; Groom & Lake: 573, 578.
1922 *Strophomena antiquata* Sowerby; Wills & Smith: 191 (pars).
1922 *Rafinesquina expansa* (?) Sowerby; Wills & Smith: 191 (pars).

DIAGNOSIS. Gently convexo-plane *Strophomena* with transverse semi-circular outline and well differentiated parvicostellate ornament, differing from *S. cancellata* in the longer brachial valve and shorter ventral muscle field.

MATERIAL AND HORIZON. Internal and external moulds of 15 pedicle and 20 brachial valves from throughout the Dolhir Formation.

DESCRIPTION. Convexoplanar shells of transversely semi-circular outline; maximum width along hinge-line or just anterior to it. Pedicle valve about seven-tenths as long as wide; lateral and anterior profiles flat except for slight convexity around umbo. Interarea high, flat, apsacline; delthyrium almost completely closed by convex pseudodeltidium. Supra-apical foramen. Brachial valve about four-fifths as long as wide and about one-tenth as deep as long; both profiles gently convex with some young forms displaying an initial median sulcus which fades by about 8 mm growth stage. Interarea short, flat, anacline; notothyrium and cardinal process lobes partially covered by convex chilidium. Unequally parvicostellate ornament yielding counts of 4–6 ribs per mm anteromedianly at 5 mm growth stage on 10, 12, 2 valves respectively. Radial ornament crossed by fine concentric lines with a density of about 7 per mm.

Ventral interior with large teeth supported by low, widely divergent dental plates. Subpentagonal muscle field poorly defined, about as long as wide and about three-tenths as long as valve; elongately oval adductor scar enclosed by diductor lobes. Some specimens with short, thick pedicle tube. Dorsal interior with conjunct cardinal process lobes each with median groove on posteroventral surface; deep sockets defined by strong socket ridges about three-tenths as wide as valve; curving laterally to lie parallel to hinge-line. Flabellate adductor scars, about three-fifths as long as wide and one-quarter as long as valve, divided longitudinally by faint median ridge. Faint traces of vascula media extending from anterior end of muscle field.

DIMENSIONS

	length	width
Internal mould of a pedicle valve, holotype, BB69202	16·0	25·6
Internal mould of a brachial valve, BB69203	26·5	34·4
Internal mould of a brachial valve, BB69204	22·6	31·5
Internal and external moulds of a pedicle valve, BB69206	—	22·8

DISCUSSION. The Glyn Ceiriog *Strophomena* can be compared to *S. cancellata* (Portlock, 1843), which is regarded as a senior synonym of *S. bilix* (Lamont, 1935) by Mitchell (1977). Both these forms, from Pomeroy and Girvan, appear to be members of the *S. norvegica* Spjeldnaes (1957 : 144) species group which includes forms characterized by a transverse outline, gently convexo-concave profile and well differentiated parvicostellate ornament. The Welsh species differs from *S. cancellata* in having a relatively longer brachial valve and relatively shorter ventral muscle field. 15 Welsh brachial valves have a mean length : width ratio of 83·6 (var. 343·63)% compared to a mean of 61·4 (var. 49·53)% for 9 Pomeroy specimens, and a 't' test on these data shows a significant difference between the two forms ($P < 0{\cdot}001$). Two Irish pedicle valves have length of muscle scar : valve length ratios of 46, 50% respectively; 9 Glyn Ceiriog specimens give ratios of 25, 26, 28, 28, 28, 33, 36, 37, 40% for the same statistic. Therefore, while the Welsh form is closely related to *S. cancellata* it is not conspecific with it and can be distinguished on the above characters.

The Glyn Ceiriog *Strophomena* can also be distinguished from other British species: *S. deficiens* Reed, 1917 is strongly convexo-concave, has stout cardinal process lobes and a longer ventral muscle field, as has *S. norvegica lata* Williams, 1962 and *S. grandis* (Sowerby, 1839). *S. shallockiensis* Davidson, 1883 differs in its larger ventral interarea and lack of pseudodeltidium. Contemporary American species, such as *S. fluctuosa* Billings, 1860 and *S. platycorrugata* Twenhofel, 1928 differ in the form of their shells, while Scandinavian species, such as *S. norvegica* Spjeldnaes, 1957 and *S. hirsuta* Spjeldnaes, 1957 can be distinguished by their shell shape and the form of their cardinalia.

GUNNARELLA Spjeldnaes, 1957

Gunnarella sp.

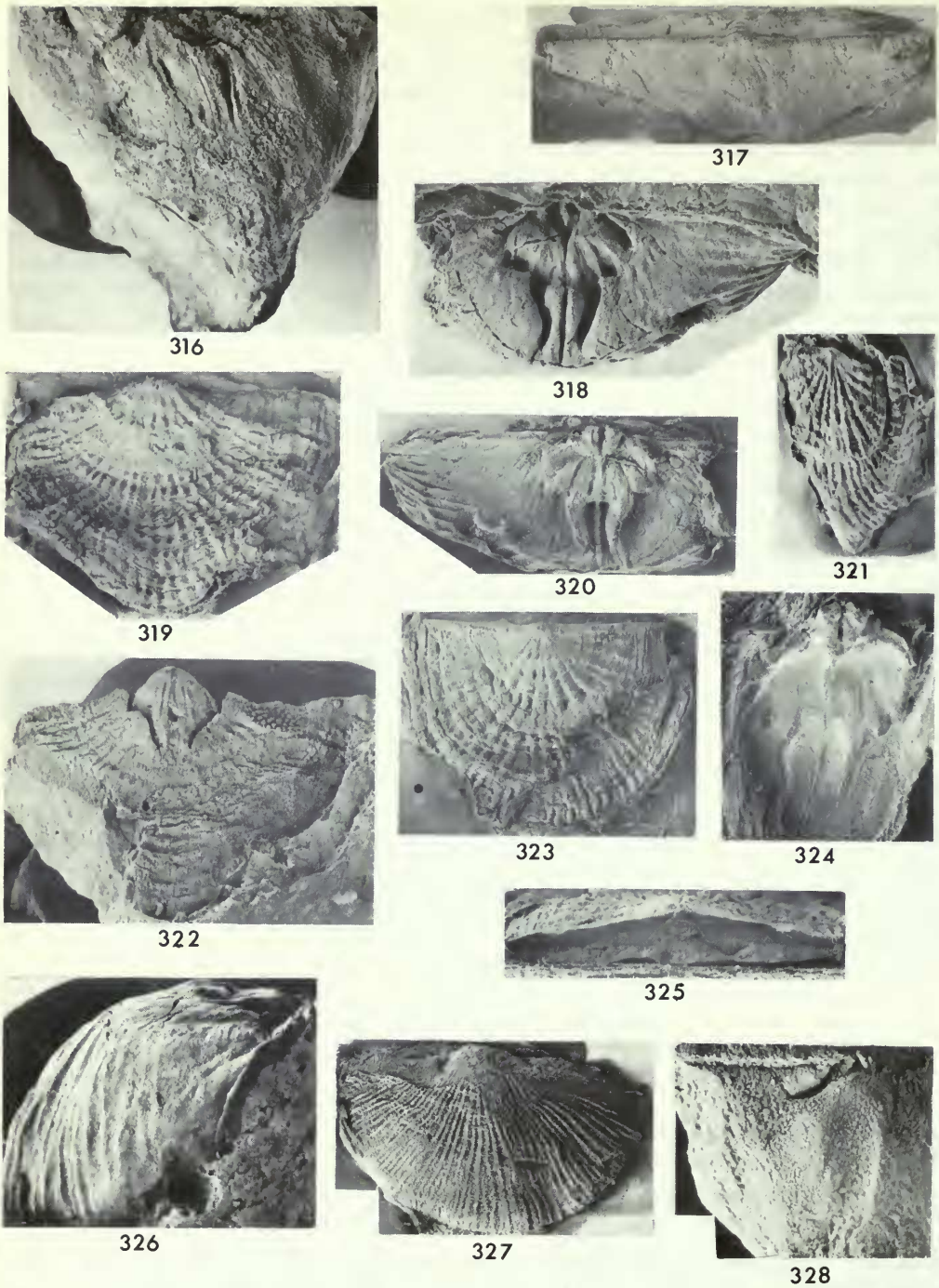
Figs 313, 314

?1908 *Rafinesquina corrugatella* Davidson; Groom & Lake: 573.
?1922 *Stropheodonta corrugatella* (Davidson); Elles: 172.

MATERIAL AND HORIZON. A single broken specimen of a brachial valve, BB69209, comprising both internal and external moulds, from a horizon 16 m above the Dolhir Limestone.

DESCRIPTION. Gently convex brachial valve, slightly concave umbonally, of approximately semicircular outline. Ornamentation of fine parvicostellae segregated into narrow sectors by about 16 thickened costellae which interrupt fairly strong concentric rugae. These have a density of about 3 per mm anteriomedianly at 5 mm growth stage and the sectors contain about six ribs each at this same stage.

Dorsal interior with small sockets defined by widely divergent socket ridges which curve posterolaterally to lie parallel with hinge-line. Cardinal process obscure. Notothyrial platform slightly thickened. Musculature not seen.



Figs 316–317 ?*Luhaia* sp. Dolhir Formation: Fig. 316, BB69210, Internal mould of a brachial valve, ×1·5, loc. D15. Glyn Formation: Fig. 317, BB69211, Latex cast of the posterior end of a pair of conjoined valves, ×1·5, loc. G2.

Figs 318–326 *Katastrophomena dolhirensis* sp. nov. Dolhir Formation: Fig. 322, Holotype, BB69215, Internal mould of a pedicle valve, ×2·0, loc. D6; Fig. 319, Holotype, BB69215, Latex cast of the exterior of a pedicle valve, ×2·0, loc. D6; Figs 318, 320, BB69213, Internal mould and latex cast

DISCUSSION. The distinctive ornament of this specimen is enough to identify it as *Gunnarella* but more material is necessary before a more precise identification can be made.

LUHAIA Rõõmusoks, 1956

?*Luhaia* sp.
Figs 315–317

MATERIAL AND HORIZON. Internal and external moulds of 2 damaged brachial valves, one from the top of the Dolhir Formation, BB69210, the other from the Glyn Formation, BB69211 (width about 44 mm).

DESCRIPTION. Pedicle valve interarea quite long, flat, apsacline; delthyrium closed by pseudodeltidium. Brachial valve convex, broadly triangular in outline, with sharp, ventrally directed geniculation; maximum width along hinge-line. Lateral profile flat to gently convex until commissure is sharply deflected ventrally and develops broad median fold. Interarea short, flat, anacline; notothyrium covered by convex chilidium. Ornament, seen only on one small portion of shell near valve margin, consists of strong costellae crossed by faint concentric rugae (?).

Dorsal interior with long, narrow pair of anterior adductor scars separated by low, thin median septum and bounded laterally by low, gently curved ridges. Cardinalia and posterior adductor scars broken off both specimens.

DISCUSSION. These specimens are tentatively assigned to *Luhaia* on the basis of their strong ventral geniculation with folded trail. However, some North American species of *Strophomena*, particularly *S. fluctuosa* Billings, 1860 (Macomber, 1970 : 440), have been described as having features typical of *Luhaia*, the main difference being the well developed parvicostellate ornament of the American shells. *L. vardi* Rõõmusoks, 1956, the type species, develops a very faint parvicostellate ornament and it may be that the coarse preservation of the available Glyn Ceiriog exteriors does not show this, but the typical concentric rugae are not preserved either. It is possible that the longitudinal striations seen on the trail of one internal mould (BB69210) represent the impressions of *vascula terminalia* but apparently corresponding striations are observed on the fragmentary counterpart.

Subfamily **FURCITELLINAE** Williams, 1965

KATASTROPHOMENA Cocks, 1968

Katastrophomena dolhirensis sp. nov.
Figs 318–326

1908 *Strophomena antiquata* Sowerby; Groom & Lake: 573 (pars).
1922 *Strophomena antiquata* Sowerby; Wills & Smith: 191 (pars).

DIAGNOSIS. Resupinate to ventrally geniculate *Katastrophomena* with ornament of coarse irregular costellae and characterized by strongly developed lamellose growth lines.

MATERIAL AND HORIZON. Internal and external moulds of 32 pedicle and 25 brachial valves from the lower part of the Dolhir Formation, including the Dolhir Limestone Member.

DESCRIPTION. Variably resupinate shells of transversely subquadrate outline; maximum width on or immediately anterior to hinge-line; cardinal angles normally rectangular to roundedly

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of a brachial valve, ×2·3, ×2·1, loc. D6; Fig. 321, BB69214, Latex cast of the exterior of a brachial valve, ×1·5, loc. D6; Figs 324, 326, BB69214, Internal mould and latex cast of a brachial valve, ×2·5, ×3·0, loc. D6; Figs 323, 325, BB69212, Latex cast of the exterior of a pedicle valve, ×1·9, ×2·4, loc. D1.

Figs 327–328 *Mjoesina marri* sp. nov. Cyrn-y-brain Formation: Fig. 327, BB69220, Latex cast of the exterior of a pedicle valve, ×2·1, loc. C6; Fig. 328, BB69221, Broken internal mould of a brachial valve, ×4·5, loc. C6.

obtuse. Pedicle valve over three-quarters as long as wide; lateral profile ranging from flat to resupinate with maximum convexity at umbo, decreasing anteriorly until valve may become distinctly concave, almost geniculate; anterior profile gently convex becoming concave posterolaterally; faint, broad sulcus may develop on geniculate part of older shells and may form tongue-like projection. Interarea short, about one-seventh as long as valve, curved apsacline; wide delthyrium partially closed by convex pseudodeltidium. Brachial valve nearly nine-tenths as long as wide; lateral profile slightly concave umbonally, commonly geniculate in ventral direction; anterior profile convex with flattened median portion; small fold developed on trail of 4 out of 9 geniculate specimens. Interarea very short, flat, anacline; notothyrium covered by prominent convex chilidium with slight median groove. Ornament of coarse, rounded costellae which increase both by branching and intercalation from 10–11 initial costae; density of 1–2 ribs per mm 5 mm anteromedianly from ventral umbo. Well developed concentric ornament of closely spaced filae, 10–12 per mm at 5 mm growth stage, and prominent growth lines commonly extended into frilly lamellae, especially in later growth stages. Tendency for hollow spines to form where growth lines cross costellae.

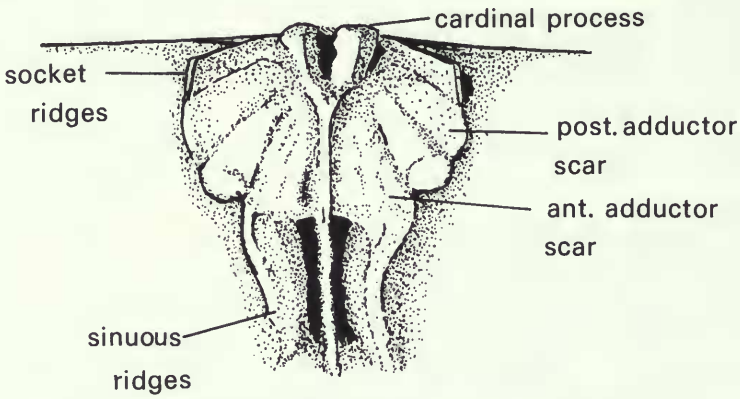


Fig. 10 Diagrammatic view of the dorsal interior of *Katastrophomena dolhirensis* sp. nov.

Ventral interior with strong teeth supported by low, widely divergent, receding dental plates which give rise to pair of inclined ridges at lateral edges of large sub-pentagonal muscle field. Muscle field about nine-tenths as long as wide and one-third as long as valve; well developed diductor lobes separated by low ridge on which is situated narrow adductor scar. Thick *vascula media* extend from anterior edge of muscle field. Dorsal interior with pair of strong, conjunct cardinal process lobes and widely divergent (c. 115°) socket ridges about two-fifths as wide as valve. Muscle field situated on platform of secondary shell, bisected by low median septum; posterior and anterior adductor scars separated by low diagonal ridge, possibly connected with *vascula myaria*, which terminates in stubby spine at anterolateral corner of platform. From anterior edge of platform pair of sinuous ridges extend anteriorly to over one-half of valve length. These bound long, narrow subrectangular area which is bisected by continuation of median septum (Fig. 10).

DIMENSIONS

	length	width
Internal and external moulds of a pedicle valve, holotype, BB69215 .	17·9	24·4
External mould of a pedicle valve, BB69212	15·0	22·0
Internal and external moulds of a brachial valve, BB69214 . .	20·0	—

DISCUSSION. This distinctive genus is fairly common in the lower part of the Dolhir Formation, above and below the Dolhir Limestone. However, it has not as yet been recorded from the upper part of the formation or from the Fron Frys Formation. One poorly preserved specimen from the Glyn Formation is tentatively assigned to the genus. It is a distinct species showing strong

morphological resemblance to *Katastrophomena woodlandensis* (Reed, 1917), the type for the genus, and can be distinguished from the known Silurian species mainly by its more elaborate ornament. *K. woodlandensis* does not develop prominent lamellose growth lines and the ventral muscle field shows differences in size and shape with that of the Glyn Ceiriog form which, in these respects more closely resembles *K. woodlandensis geniculata* (Williams, 1951) and *K. scotica* (Bancroft, 1949). Apart from the lack of lamellose growth lines the brachial valve of the latter is not geniculate, neither is the dorsal muscle platform so well developed. *K. penkillensis* (Reed, 1917) is separated from all the other species by its well differentiated parvicostellate ornament.

Katastrophomena has not previously been recorded from the Ordovician, although records of '*Strophomena antiquata*' are widespread. Whether these shells are conspecific with *K. dolhirensis* sp. nov. remains to be seen.

Recently, Bassett (1974 : 106) described several subspecies of *K. antiquata* (Sowerby, 1839) from the Wenlock strata of south Wales and the Welsh Borderland. In his description of the muscle fields he gives a different interpretation of the distribution of the muscles to that given here which is more like the interpretation of Cooper (1956) in his descriptions of species of *Strophomena*. Bassett (ibid : 108) states that the anterior adductor scars are sited between the pair of sinuous ridges and separated by the median septum. This seems unlikely, although the anterior scars may extend along the sinuous ridges for a short way. However, more research on this and related genera is required before this problem can be resolved.

The following statistical data were obtained for the sample:

Pedicle Valve

Length of valve (l) : width of valve (w), n = 21; $\bar{l}$(var. l) = 14·4 (30·31) mm; $\bar{w}$(var. w) = 19·5 (51·42) mm; r = 0·522; a(var. a) = 1·30 (0·065).

Length of valve (l) : length of muscle field (m), n = 14; $\bar{l}$(var. l) = 14·4 (41·40) mm; $\bar{m}$(var. m) = 4·6 (3·86) mm; r = 0·915; a(var. a) = 0·31 (0·0013).

Length of muscle field (l) : width of muscle field (w), n = 18; $\bar{l}$(var. l) = 4·8 (3·43) mm; $\bar{w}$(var. w) = 5·5 (4·30) mm; r = 0·763; a(var. a) = 1·12 (0·033).

Brachial Valve

Width of valve (w) : width of socket ridges (s), n = 12; $\bar{w}$(var. w) = 17·8 (47·59) mm; $\bar{s}$(var. s) = 6·9 (4·95) mm; r = 0·937; a(var. a) = 0·32 (0·0013).

Length of valve (l) : length of muscle field (m), n = 11; $\bar{l}$(var. l) = 13·7 (17·59) mm; $\bar{m}$(var. m) = 7·2 (2·42) mm; r = 0·632; a(var. a) = 0·37 (0·0092).

Subfamily **RAFINESQUININAE** Schuchert, 1893

KJAERINA Bancroft, 1929

Kjaerina sp.

Figs 405–408

1908 *Rafinesquina deltoidea* Conrad; Groom & Lake: 573 (pars).

Material and horizon. Internal and external moulds of 4 pedicle valves (e.g. BB69217, l = 11·5, w = 9·4; BB69218, w = 11·1, l = 70·4) and 2 brachial valves from the lower part of the Dolhir Formation 16 m above the Dolhir Limestone.

Description. Concavo-convex shells of elongately subquadrate outline; maximum width along hinge-line which may be slightly mucronate. Pedicle valve about nine-tenths as wide as long and one-tenth as deep as long; gently convex in both profiles. Interarea short, flat, orthocline. Brachial valve also about nine-tenths as wide as long; gently concave in both profiles. Interarea very short, flat, anacline. Ornamentation finely, unequally, parvicostellate with conspicuous thickened median costa.

Ventral interior with short, widely divergent dental plates less than one-tenth as long as valve. Poorly defined muscle field sometimes divided longitudinally by faint, short median ridge. Dorsal interior with pair of delicate, plate-like cardinal process lobes diverging anteriorly; socket ridges widely divergent, about one-sixth as wide as valve. Musculature not seen.

Discussion. Such a limited sample cannot be assigned to any species with certainty; indeed it was only after some difficulty that the generic assignment was determined. Bancroft (1945 : 246) listed a number of characters which, in association with one another, serve to distinguish between *Kjaerina* and *Rafinesquina*. They are: (1) the smaller size and more delicate cardinalia of *Kjaerina*; (2) the presence of a strong median rib on the pedicle valve of *Kjaerina*; (3) the ventral muscle field of *Rafinesquina* is large and flabellate; in *Kjaerina* the muscle field is restricted by the narrowly divergent plates; (4) the dorsal muscle field more deeply impressed in *Rafinesquina*; (5) *Kjaerina* interiors always show traces of the external ornament and the vascular markings are not seen.

Some of these points, especially 4 and 5, depend largely on preservation, but Bancroft does not mention the strong posterolateral rugae used by Williams (1965 : H388) to separate the genera. The Dolhir Formation specimens conform closely to Bancroft's diagnosis of *Kjaerina* and, despite the absence of posterolateral rugae, are placed in that genus.

Subfamily **GLYPTOMENINAE** Williams, 1965

MJOESINA Spjeldnaes, 1957

Mjoesina marri sp. nov.
Figs 327–330

Diagnosis. Transversely elliptical *Mjoesina* characterized by large ventral muscle field in which the adductors are not enclosed by diductors; and an ornament which is undifferentiated into sectors by enlarged costae or costellae.

Material and horizon. Internal and external moulds of 11 pedicle and 2 brachial valves from the top of the Dolhir and Cyrn-y-brain Formations.

Description. Strongly ventri-biconvex to plano-convex shells of transversely elliptical outline. Maximum width anterior to hinge-line, cardinal angles obtuse. Pedicle valve over three-quarters as long as wide and one-third as deep as long; lateral profile strongly convex with no distinct geniculation; anterior profile with maximum convexity medianly. Interarea flat, orthocline to slightly apsacline, about one-tenth as long as valve; wide delthyrium with small apical pseudodeltidium. Brachial valve represented by only two fragmentary specimens which appear to be flat umbonally. Interarea short, flat, catacline; notothyrium covered by small, convex chilidium. Ornamentation of fine costae and costellae, arising mostly by intercalation, with density of 4–5 ribs per 2 mm, 7·5 mm anteromedianly from ventral umbo. Ribs not differentiated into sectors by accentuated costae or costellae.

Ventral interior with large, strongly impressed, subpentagonal muscle field almost as wide as long and nearly two-fifths as long as valve. Narrow median adductor scars extend beyond broad diductor lobes; whole muscle field bisected longitudinally by narrow median ridge. Strong teeth supported by widely divergent dental plates which give rise to ridges defining muscle field. One specimen shows short, thick pedicle tube. Thick *vascula media* extend from anterior end of adductor scars.

Dorsal interior with small, discrete cardinal process lobes; socket ridges curve posterolaterally to lie parallel with hinge-line. Broad, rounded ridge extending anteriorly from notothyrial platform; muscle scars not well defined.

Dimensions

	length	width
Internal mould of a pedicle valve, holotype, BB69219	17·5	24·4
External mould of a pedicle valve, BB69220	13·3	21·6
Internal mould of a brachial valve, BB69221	—	—
Internal mould of a pedicle valve, BB69222	25·6	40·8

Discussion. *Mjoesina* is best known from the Caradoc of Girvan and Oslo; there is only one record from the Ashgill: from Pomeroy (Mitchell, 1977). The Welsh species differs in having a shallower pedicle valve, being one-third as deep as long compared to over one-half as deep as long for the Irish species, and the ventral muscle field of the Welsh form is relatively narrower.

However, the single Irish specimen does not allow these differences to be tested statistically.

The better known Caradoc species can be roughly separated into two groups on the basis of the brachial valve profile and relative size of the ventral muscle field (Mitchell, 1977 : 101). The fragmentary Welsh brachial valves cannot be referred to either group but the large ventral muscle field is more like that of the Oslo group which includes *M. mjoesensis* (Holtedahl, 1916) and *M. gregaria* Spjeldnaes, 1957. The principal difference between these and the Welsh specimens is the differentiation of the ornament into sectors bounded by enlarged costae or costellae, and a deeper pedicle valve in the case of *M. mjoesensis*. In the ventral muscle fields of these two species the adductor scars are enclosed by the diductor lobes.

The following statistical data were obtained for the sample:

Pedicle Valve

Valve length (l) : valve width (w), n = 8; $\bar{l}$(var. l) = 19·38 (22·156) mm; $\bar{w}$(var. w) = 26·49 (77·887) mm; r = 0·5603; a(var. a) = 1·875 (0·4019).

Valve length (l) : valve depth (d), n = 8; $\bar{l}$(var. l) = 19·38 (22·156) mm; $\bar{d}$(var. d) = 6·59 (11·51) mm; r = 0·5228; a(var. a) = 0·7207 (0·0629).

Valve length (l) : length of muscle field (m), n = 8; $\bar{l}$(var. l) = 19·46 (21·003) mm; $\bar{m}$(var. m) = 7·34 (8·574) mm; r = 0·7149; a(var. a) = 0·639 (0·0333).

Length of muscle field (m) : width of muscle field (f), n = 10; $\bar{m}$(var. m) = 6·84 (7·929) mm $\bar{f}$(var. f) = 6·16 (4·074) mm; r = 0·9162; a(var. a) = 0·717 (0·0103).

Family **CHRISTIANIIDAE** Williams, 1953

CHRISTIANIA Hall & Clarke, 1892

Christiania sp.

Figs 331–335

Material and horizon. Internal and external moulds of 9 pedicle and 3 brachial valves from the lower and middle parts of the Dolhir Formation, above the Dolhir Limestone.

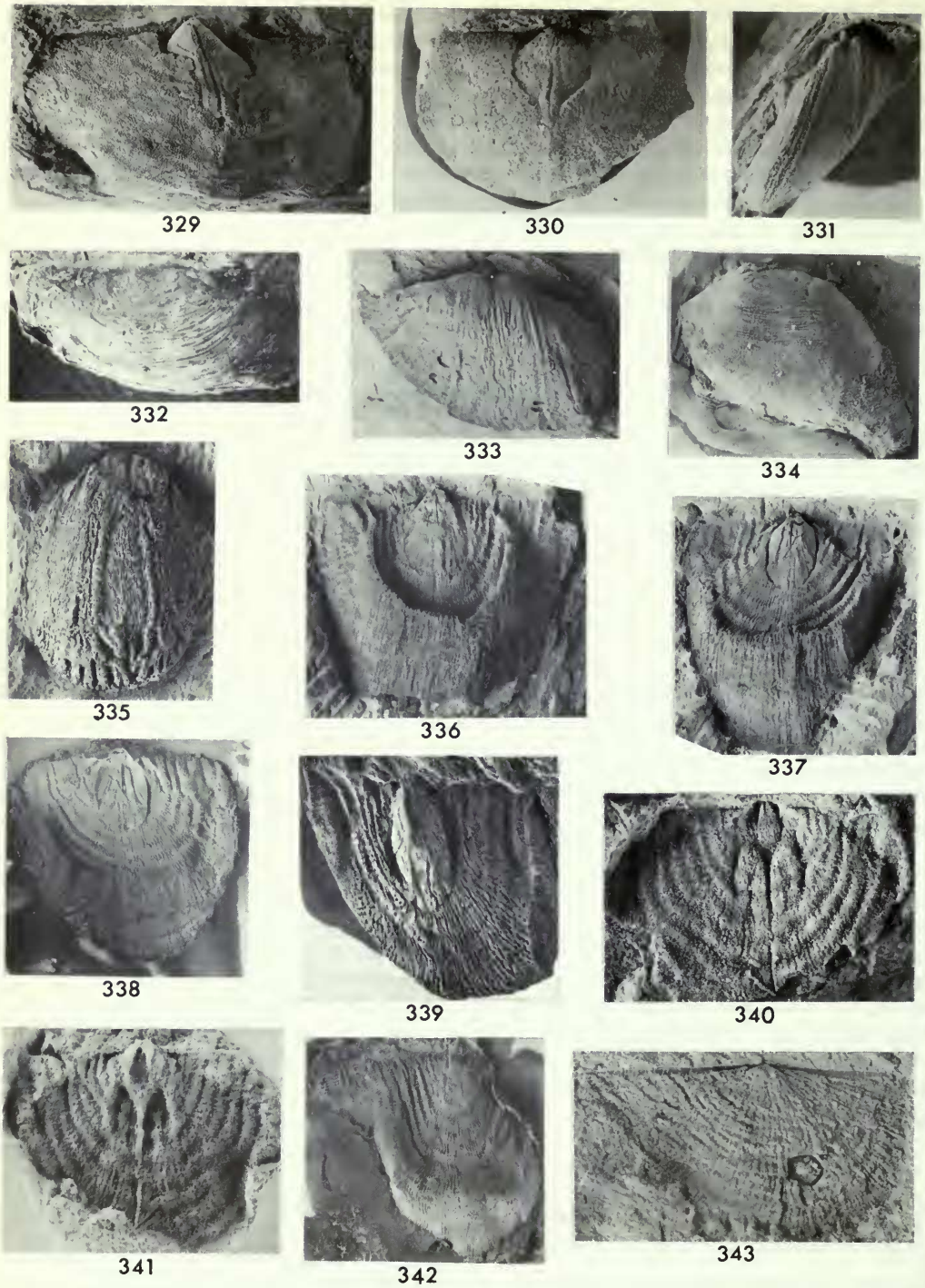
Description. Concavo-convex shells of elongately subquadrate outline with maximum width anterior to hinge-line. Pedicle valve about nine-tenths as wide as long and one-third as deep as long; lateral profile moderately convex; anterior profile strongly convex. Interarea flat, orthocline; delthyrium closed by convex pseudodeltidium perforated by small, circular apical foramen. Brachial valve about as long as wide, strongly concave in both profiles. Ornamentation of fine anastamosing concentric ridges with density of 5–8 per mm on 1, 1, 2, 1 valves at 5 mm growth stage.

Ventral interior with pedicle tube tapering posteriorly; teeth quite strong but dental plates obsolete; pair of subcircular diductor scars situated posteriorly on either side of short median ridge. Pair of thick, deeply impressed *vascula media* diverging slightly from diductor scars and seen to branch anteriorly. Internal surface of valve covered in elongate papillae (pseudopunctae?). Dorsal interior represented by single poorly preserved specimen showing only inner and lateral septa and fragment of a socket ridge joined to lateral septum.

Dimensions

	length	width
Internal mould of a pedicle valve, BB69224	9·5	11·3
External mould of a pedicle valve, BB69225	—	13·8
Internal mould of a pedicle valve, BB69226	17·0	12·5
External mould of a brachial valve, BB69228	5·0	10·9

Discussion. The subquadrate shape and absence of radial ornament of this species of *Christiania* separate it from most other species except *Christiania* sp. (Wright, 1963 Ms) from Portrane, *C. portlocki*, Mitchell, 1977 from Pomeroy and *C. nilssoni* Sheehan, 1973 from Sweden. The crushing of the Welsh specimens rules out any statistical comparison of shell shape with these other species but the simpler development of septa in the brachial valve, poorly seen in the single dorsal interior available, suggests affinity with the Pomeroy form. However, all three of these



Figs 329–330 *Mjoesina marri* sp. nov. Cyrn-y-brain Formation: Fig. 329, BB69222, Internal mould of a pedicle valve, ×1·2, loc. C6; Fig. 330, Holotype, BB69219, Internal mould of a pedicle valve, ×1·5, loc. C6.

Figs 331–335 *Christiania* sp. Dolhir Formation: Fig. 331, BB69227, Internal mould of a pedicle valve, ×2·4, loc. D6; Fig. 332, BB69228, External mould of a brachial valve, ×3·8, loc. D5;

species develop a sulcus in the pedicle valve, which is not in the Glyn Ceiriog shells. Another form similar to the Welsh one is *C. holtedahli* Spjeldnaes, 1957 but the transverse septum joining the inner and lateral septa is not seen in the Glyn Ceiriog specimen. Further well preserved dorsal interiors are required before the specific identity can be more satisfactorily assessed.

Family **LEPTAENIDAE** Hall & Clarke, 1894

LEPTAENA Dalman, 1828

Leptaena cf. ***rugosa*** Dalman, 1828
Figs 336–342

cf. 1828 *Leptaena rugosa* Dalman: 106, pl. 1, fig. 1.
1908 *Leptaena rhomboidalis*, Wilckens; Groom & Lake: 572, 577.
1922 *Leptaena rhomboidalis*, Wilckens; Wills & Smith: 187, 191.

MATERIAL AND HORIZON. *Leptaena* is one of the most commonly occurring genera in Glyn Ceiriog district, being found throughout the Dolhir Formation, Glyn Formation and Fron Frys Formation. It is also a common form in the Cyrn-y-brain Formation. The sample consists of 56 pedicle and 30 brachial valves and a number of fragments, mostly of exteriors.

DESCRIPTION. Concavo-convex, transversely subquadrate, dorsally geniculate *Leptaena* with maximum width along hinge-line; strongly raised marginal ruga on pedicle valve and corresponding deep groove on brachial valve delimiting discs. Ventral disc about two-thirds as long as wide, faintly convex umbonally; trail subtends angle of about 125° with disc, although there is some variation in this. Pedicle valve about three-quarters as long as wide with alate hinge-line. Interarea short, flat, apsacline; delthyrium with small apical pseudodeltidium. Trail typically without undulations. Brachial valve slightly concave, two-thirds as long as wide. Interarea very short, flat, anacline; notothyrium closed by strongly arched chilidium bearing median groove. Ornament of regularly developed concentric rugae, wavelength about 1 mm at 5 mm growth stage, with 5–11 present on disc, very faint near umbo; also fine costellate radial ornament yielding counts of 4–5 ribs per mm at 5 mm growth stage.

Ventral interior with large subquadrate muscle field just over four-fifths as wide as long and just over two-fifths as long as valve. Narrow adductor scars situated posteromedianly, separated by short, low septum and enclosed almost entirely by semiflabellate diductors. Teeth small, supported by widely divergent dental plates from in front of which sinuous ridges surround muscle field. In a few specimens papillae (?pseudopunctae) are seen to be roughly arranged into concentric rows approximately corresponding to rugae on external surface. Rugae clearly visible on valve interiors.

Dorsal interior with prominent cardinal process lobes diverging at about 50° sometimes separated by thin septum underlying median groove on chilidium. Socket ridges weakly developed and often obscured by secondary shell material; sockets small. Two pairs of laterally disposed, oval-shaped adductor scars defined by three ridges originating from notothyrial platform; median ridge narrows anteriorly and extends to front margin of disc as low, thin septum. Faint traces of trans muscle septa seen, in one specimen, to separate anterior and posterior parts of scars. Muscle field almost as wide as long and over one-third as long as valve.

Fig. 333, BB69224, Internal mould of a pedicle valve, ×3·0, loc. D6; Fig. 334, BB69225, Latex cast of the exterior of a pedicle valve, ×2·5, loc. D5; Fig. 335, BB69226, Internal mould of a pedicle valve, ×2·2, loc. D6.

Figs 336–342 *Leptaena* cf. *rugosa* Dalman. Dolhir Formation: Fig. 336, BB69237, Internal mould of a pedicle valve, ×1·7, loc. D15; Figs 337, 338, BB69235, Internal mould and latex cast of a pedicle valve, ×1·6, loc. D15; Fig. 339, BB69230, Internal mould of a pedicle valve, ×2·3, loc. D6. Cyrn-y-brain Formation: Figs 340, 341, BB69234, Internal mould and latex cast of a brachial valve, ×2·3, loc. C2; Fig. 342, BB69238, Latex cast of the exterior of a pedicle valve, ×1·0, loc. C2.

Fig. 343 Leptaenid gen et sp. indet. Dolhir Formation: BB69240, Internal mould of a pedicle valve, ×2·4, loc. D15.

DIMENSIONS

	length	width
Internal mould of a pedicle valve, BB69230	15·2	18·7
Internal mould of a pedicle valve, BB69235	24·4	21·9
Internal mould of a pedicle valve, BB69237	19·2	23·5
External mould of a pedicle valve, BB69238	19·3	c. 22

DISCUSSION. A large number of the specimens have been deformed so that some specimens have trails bearing undulations and one specimen has a deeply indented anterior margin. There is also considerable variation within the sample, but to what extent this is a reflection of deformation is uncertain and so any statistical comparison may be tentative. However, the major features are well enough preserved to allow comparisons to be made with other stocks. The large subquadrate ventral muscle scar and large range in numbers of rugae, 5 to 11 on 3, 9, 14, 9, 5, 6, 2 pedicle valves, suggest the nearest relatives are to be found amongst *L. rugosa* Dalman, *L. salopiensis* Williams and *L. valentia* Cocks. The two latter forms differ in that their trails are more sharply bent back, subtending angles of 100° and 90° to the disc respectively, compared with 125° in the Glyn Ceiriog form; according to Spjeldnaes (1957 : 173) the trail of *L. rugosa* subtends an angle of 120° or more with the disc. Further, the dorsal adductor scars of *L. valentia* taper forwards, whereas in the Glyn Ceiriog specimens they expand anteriorly.

Mitchell (1977 : 108) gave some statistics for the pedicle valves of *L.* cf. *rugosa* from Pomeroy, which do not indicate any significant difference between his form and the present specimens. In a comparison of the number of rugae on the pedicle valves, 7 and 8 are the most common numbers to be found on *L. rugosa* and *L. valentia*; for *L. salopiensis* 5 and 6 occur most frequently and in the Glyn Ceiriog sample 6, 7, and 8 are the most common numbers.

The thin posterior septum underlying the median groove on the chilidium was regarded as a distinguishing feature of *Leptaenopoma* Marek and Havlíček, 1967, but Bergström (1968 : 15) points out that this character is also seen in some specimens of *Leptaena rugosa*.

LIMBIMURINA Cooper, 1956

?*Limbimurina* sp.
Figs 344, 345, 347

MATERIAL AND HORIZON. Internal and external moulds of a single broken valve, BB69239, from the lowest part of the Dolhir Beds, just below the Dolhir Limestone.

DESCRIPTION. Brachial valve flat with fine parvicostellate ornament interrupted by faint, impersistent, concentric rugae to give a reticulate pattern on umbonal regions. Rugae die out towards shell margin. Interarea quite long, flat, anacline; notothyrium and cardinal process lobes partially covered by strongly arched chilidium with slight median furrow.

Dorsal interior with pair of large, robust cardinal process lobes and weakly developed, widely divergent socket ridges. Musculature not seen.

DISCUSSION. The ornament of this single specimen shows a strong resemblance to that of *Limbimurina*, which is unequally parvicostellate with the stronger costellae breaking up weakly developed concentric rugae into zig-zag sets especially in umbonal regions. However, this zig-zag pattern dies out anteriorly and the parvicostellate ornament becomes dominant. The specimen does not show the elaborate frill with concentric fold typical of *Limbimurina*, but about two-thirds of valve-length from umbo is a zone of crushing which may represent such a fold. Until better material becomes available the identification as *Limbimurina* must remain tentative.

Leptaenid gen. et sp. indet
Fig. 343

MATERIAL AND HORIZON. A single internal mould of pedicle valve, BB69240, from the top of the Dolhir Formation. Length 11·0 mm, width 20·5 mm.

DESCRIPTION. Very gently convex, almost flat, pedicle valve of semi-circular outline over one-half as long as wide; maximum width along hinge-line; cardinal angles acute. Interarea very short, flat, apsacline with small pseudodeltidium. Ornament, as impressed on valve interior, of fine costellate ribbing and closely spaced, concentrically disposed, impersistent rugae, irregular posterolaterally, which may interrupt radial ornament.

Rib density of about 3 per mm at 5 mm growth stage. Ventral interior with short widely-divergent dental plates supporting fairly strong teeth. Muscle field not well defined.

DISCUSSION. The well developed concentric rugation of this specimen suggests affinities with the Leptaenidae, but it lacks the typical geniculation of that family and the fairly large, well defined ventral muscle field. The widely divergent dental plates and small, poorly defined muscle field on this internal mould are more like those found among the Rafinesquininae, a group which also develops concentric rugae.

Family **STROPHEODONTIDAE** Caster, 1939

Subfamily **STROPHEODONTINAE** Caster, 1939

EOSTROPHEODONTA Bancroft, 1949

Eostropheodonta hirnantensis (M'Coy, 1851)

Figs 346, 348–353

1851 *Orthis hirnantensis* M'Coy: 219, pl. 1H, fig. 11.
1922 *Orthis hirnantensis* M'Coy; Wills & Smith: 191.
1922 *Strophomena siluriana* Davidson; Wills & Smith: 191.
1965 *Eostropheodonta hirnantensis* (M'Coy); Temple: 410, pl. 17 figs 1–6, pl. 18, figs 1–7, pl. 19, figs 1–5.

MATERIAL AND HORIZON. Internal and external moulds of 12 pedicle and 2 brachial valves from the top of the Cyrn-y-brain Formation and Plas Uchaf Formation and 1 brachial valve from the Glyn Formation.

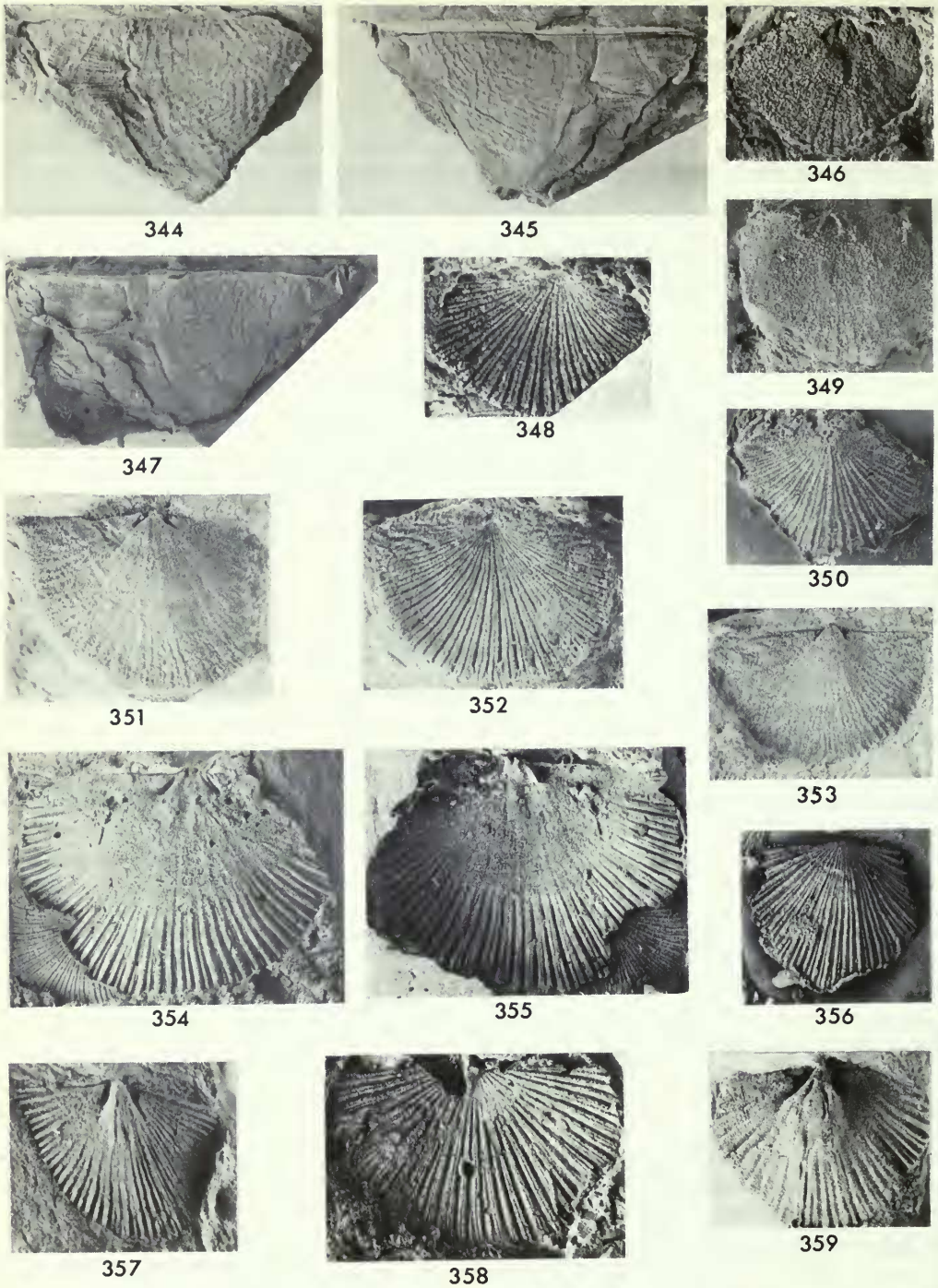
DESCRIPTION. Concavo-convex shells of transversely subquadrate outline; maximum width anterior to hinge-line. Pedicle valve nearly four-fifths as long as wide and about one-fifth as deep as long. Gently convex in both profiles; maximum convexity around umbo. Interarea short, flat, orthocline; delthyrium open. Brachial valve about three-quarters as long as wide; very gently concave. Interarea very short, flat, anacline; notothyrium closed by small convex chilidium. Unequally parvicostellate ornament yielding counts of 3–5 ribs per mm on 4, 1, 1 valves respectively, 5 mm anteromedianly from umbo; cancellated by fine concentric filae. Faint posterolateral rugae seen on some specimens.

Ventral interior with short dental plates diverging anteriorly at 60°–70° and extending for about one-tenth of valve length. Details of musculature not seen. Dorsal interior with plate-like cardinal process lobes diverging anteriorly at about 50°. Socket ridges widely divergent (c. 100°), about three-tenths as wide as valve, with about 4 denticles on posterior surface. Musculature obscure.

DIMENSIONS

	length	width
Internal mould of a brachial valve, BB69243	5·8	8·5
External mould of a pedicle valve, BB69244	5·1	8·2
Internal and external moulds of a pedicle valve, BB69245	7·5	11·2

DISCUSSION. The Cyrn-y-brain specimens can be compared to *E. hirnantensis* (M'Coy 1851) and the closely related *E. siluriana* (Davidson, 1871). These two forms are very similar, the main difference between them being the coarser, more fascicostellate ribbing of the latter; a more detailed comparative study of the two is required. The fine parvicostellate ornament of the Cyrn-y-brain form would indicate a closer affinity with *E. hirnantensis* but there are some differences with previous descriptions of that species. However, a number of descriptions of *E. hirnantensis* e.g., Temple (1965 : 394), Bergström (1968 : 10) show that it must be a variable form; it has been described as plano-convex and concavo-convex, and the ornament as unequally



Figs 344–345, 347 ?*Limbimurina* sp. Dolhir Limestone Member: Figs 345, 347, BB69239, Broken internal mould and latex cast of a brachial valve, ×1·4, ×1·3, loc. L3; Fig. 344, BB69239, Broken external mould of the same specimen, ×1·3, loc. L3.

Figs 346, 348–353 *Eostropheodonta hirnantensis* (M'Coy). Cyrn-y-brain Formation: Figs 346, 349, BB69243, Internal mould and latex cast of a brachial valve, ×3·4, loc. C3; Figs 348, 350, BB69244,

parvicostellate and fascicostellate. The number of denticles recorded on the teeth and socket ridges varies and there appears to be considerable variation on the angles of divergence of dental plates, socket ridges and cardinal process lobes. The Cyrn-y-brain specimens fall within the ranges covered by these descriptions for each of the characteristics.

Analysis of a small topotype sample of *Eostropheodonta hirnantensis* from the Hirnant Limestone has shown that the Cyrn-y-brain specimens are very similar to it. The dental plates of the Hirnant species diverge at 60°–65°, the socket ridges at c. 110° and the cardinal process lobes at 50°–55°; the profile is concavo-convex and the ornament is fascicostellate with a density of 3–4 ribs per mm, 5 mm anteromedianly from the umbo.

Superfamily **DAVIDSONIACEA** King, 1850
Family **MEEKELLIDAE** Stehli, 1954
Subfamily **FARDENIINAE** Williams, 1965

FARDENIA Lamont, 1935

Fardenia scotica Lamont, 1935
Figs 354–359

1935 *Fardenia scotica* Lamont: 311, pl. 7, figs 1–7.

MATERIAL AND HORIZON. Internal and external moulds of 6 pedicle and 5 brachial valves from the middle and upper parts of the Dolhir Formation and from the Cyrn-y-brain Formation.

DESCRIPTION. Unequally biconvex, subquadrate shells with maximum width anterior to hinge-line. Pedicle valve over four-fifths as long as wide and nearly one-quarter as deep as long. Lateral profile gently convex; anterior profile strongly convex medianly with more gently convex flanks. Interarea fairly short, flat, apsacline; delthyrium closed by convex pseudodeltidium; one small specimen shows supra-apical foramen. Brachial valve almost three-quarters as long as wide and about one-seventh as deep as long; gently convex in both profiles. Interarea very short, flat, anacline; notothyrium and cardinal process lobes partially covered by small, convex chilidium. Ornamentation of strong costellae, arising both by branching and intercalation, numbering 3–4 per mm anteromedianly on 4 and 1 valves respectively, at 7·5 mm growth stage. Finer costellae developed between stronger ribs. Radial ornament crossed by fine concentric lines on some specimens.

Ventral interior with teeth supported by dental lamellae extending for one-quarter of valve length. Pentagonal muscle field usually weakly impressed, diductor lobes extend beyond median adductor scar, one small specimen showing short pedicle tube. Dorsal interior with pair of discrete cardinal process lobes; shallow sockets defined by short, divergent, straight socket ridges about one-fifth as wide as valve. Small, weakly impressed adductor scars lie on either side of very low, short, rounded ridge, just anterior to socket ridges.

DIMENSIONS

	length	width
Internal mould of a brachial valve, BB69247	17·6	23·5
External mould of a brachial valve, BB69248	11·1	17·5
Internal mould of a pedicle valve, BB69249	10·7	13·3
External mould of a pedicle valve, BB69250	9·0	10·2
Internal mould of a pedicle valve, BB69251	11·2	13·0

External mould and latex cast of a pedicle valve, ×4·1, ×3·3, loc. C3; Fig. 353, BB69245, Internal mould of a pedicle valve, ×1·7, loc. C3; Fig. 352, BB69245, External mould of the same specimen, ×2·1, loc. C3; Fig. 351, BB69246, Internal mould of a pedicle valve, ×2·6, loc. C3.

Figs 354–359 *Fardenia scotica* Lamont. Dolhir Formation: Figs 354, 355, BB69247, Internal mould and latex cast of a brachial valve, ×1·9, loc. D13; Fig. 358, BB69248, External mould of a brachial valve, ×2·3, loc. D13; Fig. 356, BB69250, Latex cast of the exterior of a pedicle valve, ×2·4, loc. D15. Cyrn-y-brain Formation: Fig. 357, BB69249, Internal mould of a pedicle valve, ×2·4, loc. C1; Fig. 359, BB69251, Internal mould of a pedicle valve, ×2·1, loc. C3.

Discussion. The Glyn Ceiriog and Cyrn-y-brain specimens of *Fardenia* are characterized by their unequal biconvexity, relatively short ventral interarea and straight socket ridges subtending an angle of approximately 90% at the umbo. *F. scotica* Lamont, 1935 from the Lower Drummuck Group of Girvan, is the form which most closely resembles the present specimens; it is biconvex, and has a similar ornament and straight socket ridges diverging at 90° to one another. However, there is not enough data available for this comparison to be tested statistically. Both forms can easily be separated from the resupinate *F. pertinax* (Reed, 1917) and *F. geoffreyi* (Bancroft, 1949), which also have a finer parvicostellate ornament. *F. scalena* Williams, 1962 is a biconvex form but has a high ventral interarea and strongly curved socket ridges. The present specimens can be regarded as being conspecific with *F. scotica*, which has also been recorded from the Cautley and Dent districts (Ingham, 1966 : 498).

Order **PENTAMERIDA** Schuchert & Cooper, 1931
Suborder **SYNTROPHIIDINA** Ulrich & Cooper, 1936
Superfamily **PORAMBONITACEA** Davidson, 1853
Family **PORAMBONITIDAE** Davidson, 1853

PORAMBONITES Pander, 1830

Porambonites sp.
Figs 360–363

Material and horizon. Badly crushed and sheared internal moulds of 5 valves, BB69254–57, and fragments of external moulds, all from the Tyn-y-twmpath Member of the Dolhir Formation.

Description. Ornament of fine costellae with a density of about 5 ribs per mm. Interspaces between ribs occupied by circular pores numbering about 4–6 per mm. Valve interiors showing long sub-parallel plates extending for about one-half of valve length. Details of musculature not seen. Shell substance very thin.

Discussion. The highly distinctive ornament readily enables the identification of even these very poorly preserved specimens as *Porambonites*, but in many cases it is not possible to identify brachial or pedicle valves. Although the material does not lend itself to specific identification, this Baltic genus is known from several localities in rocks of Ashgill age, e.g., Cautley (zone 3); Estonia; Quebec; and Portrane, again with only shell fragments.

Family **PARASTROPHINIDAE** Ulrich & Cooper, 1938

PARASTROPHINA Schuchert & Le Vene, 1929

?Parastrophina sp.
Figs 365, 366

1922 *Parastrophina divergens* Hall & Clarke; Wills & Smith: 191.

Material and horizon. One internal mould of a pedicle valve, BB69258 (length c. 9, width 12·5), and 1 external mould of a brachial valve, BB69259 (length 8·7, width 7·8), from the top of the Dolhir Formation.

Description. Dorsi-biconvex, roundedly subpentagonal shells; maximum width anterior to mid-valve. Pedicle valve about three-quarters as long as wide and one-fifth as deep as long; gently convex in lateral profile; anterior profile gently convex with broad shallow sulcus originating about mid-valve. Brachial valve nine-tenths as wide as long and approaching one-quarter as deep as long; convex in both profiles with low fold developing from about mid-valve. Ornamentation of broad costae, 4 on brachial valve and 5 on pedicle valve, developing with fold and sulcus; otherwise shell surface is smooth except for occasional growth lines.

Ventral interior showing spondylium supported by small, short septum. Details of muscle scars obscure. Dorsal interior unknown.

Discussion. The present specimens are tentatively placed as *Parastrophina* although, without a well preserved dorsal interior displaying alate plates, the genus cannot be definitely separated from *Camerella*. There is also the problem of distinguishing between *Parastrophina* and *Parastrophinella*, which again cannot be done without a reasonably well preserved brachial valve interior (Wright, 1974 : 239).

Order **SPIRIFERIDA** Waagen, 1883
Suborder **ATRYPIDINA** Moore, 1952
Superfamily **ATRYPACEA** Gill, 1871
Family **ATRYPIDAE** Gill, 1871
Subfamily **ZYGOSPIRINAE** Waagen, 1883

CATAZYGA Hall & Clarke, 1893

Catazyga cf. ***headi*** (Billings, 1862)
Figs 370–377

cf. 1862 *Athyris headi* Billings: 147, fig 125.
cf. 1893 *Catazyga headi* (Billings); Hall & Clarke: 157, pl. 56, figs 7–11.

Material and horizon. All the specimens were recovered from the lowest part of the Dolhir Formation, mostly from the Tyn-y-twmpath Member. Most of the specimens are badly distorted. The sample consists of 18 pedicle valves (including BB69263, length 11·0 mm, width 12·7 mm), 11 brachial valves, including BB69264 and BB69266, and 8 conjoined valves, including BB69265, BB69268–9, preserved as internal and external moulds.

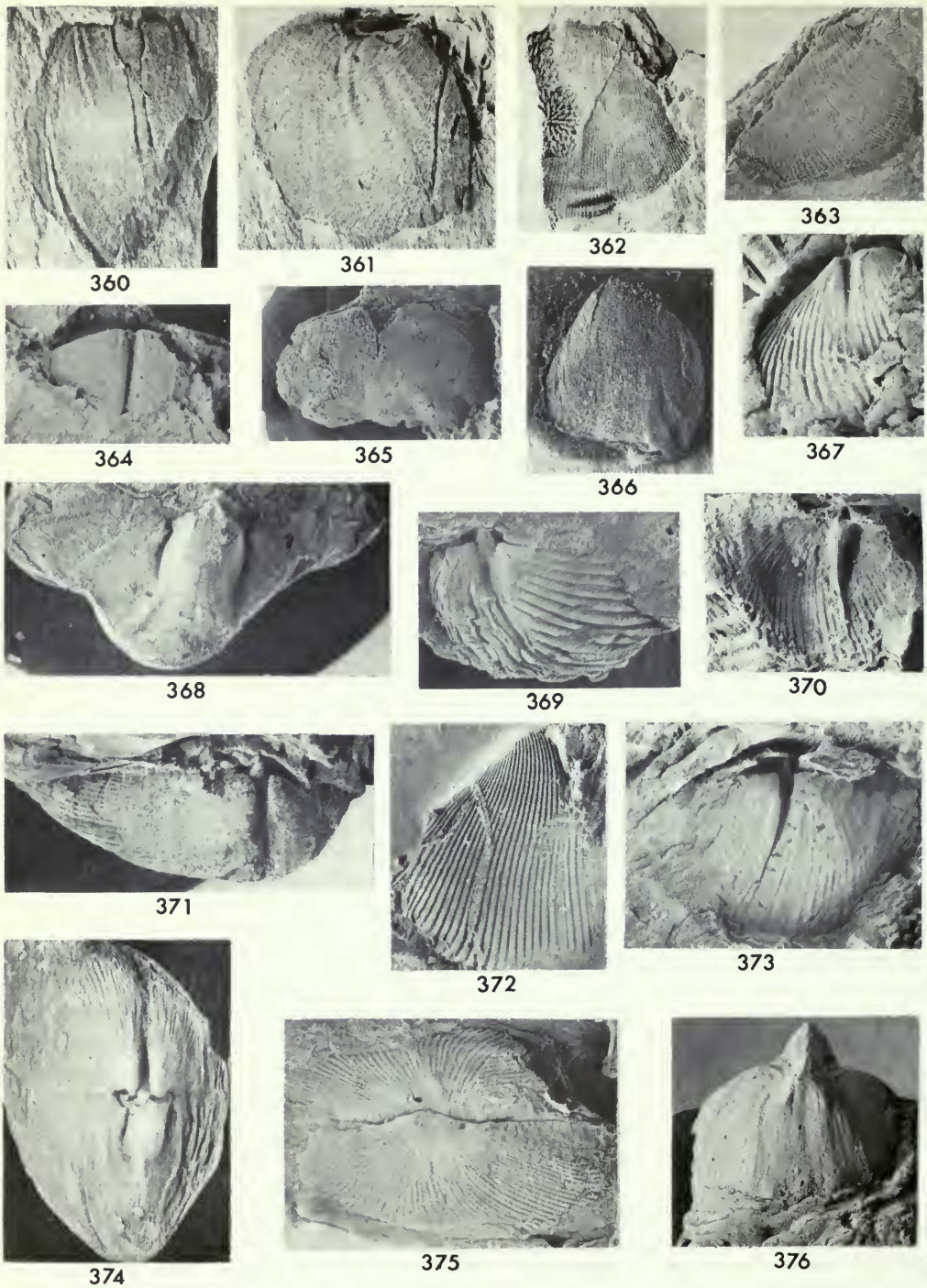
Description. Subequally biconvex shells of subcircular outline. Anterior commissure faintly sulcate. Pedicle valve slightly deeper than brachial with evenly convex lateral profile becoming strongly so posteriorly, where incurved umbo conceals dorsal beak; anterior profile more strongly convex medianly than laterally. Subcircular outline varying from slightly elongate to slightly transverse; posterior margins almost straight, making obtuse angle at umbo; lateral and anterior margins evenly rounded. Interarea very short, curved, about one-half of maximum valve width, which is located near mid-valve. Faint fold of initial stages weakening anteriorly. Brachial valve evenly convex in both profiles; grooved medianly in anterior profile by faint sulcus which becomes progressively shallower towards anterior margin. Ornament consists of 50–60 fine, rounded costae; density of about 3 ribs per mm at 5 mm growth stage. Costellae are rarely developed by splitting of primary rib (see BB69268).

Ventral interior with stout teeth supported by short dental lamellae; deep triangular pedicle chamber, about as wide as long, situated posteriorly to triangular muscle field with diductors lateral to but not as long as adductors. Brachial valve with divided hinge plate; sockets small; low median septum broad posteriorly but narrowing forwards and extending for about one-half of valve length with poorly defined adductor scars on either side.

Discussion. The most important features used in determining the specific identity of *Catazyga* are the density of ribbing and the style of fold and sulcus development.

The Glyn Ceiriog shells possess an initial sulcus in the brachial valve and complimentary ventral fold; these gradually fade anteriorly so that the anterior commissure is almost rectimarginate. The ornament is of fine costae with totals of 47, 48, 48, 50, 50, 52, 53, 54, 54, 55, 56, 58, 60 ribs in a sample of 13 valves. With rare exceptions, additional ribs do not develop with growth so that shell size is not important in consideration of this aspect; however, a density of 3, 4, 5, ribs per mm was observed at the 5 mm growth stage of 7, 3, 1 valves respectively.

The rib density of the Glyn Ceiriog species compares closely with that of *C. anglica* (Davidson, 1869), *C. arcana* Williams, 1962, *C. cartieri* Cooper & Kindle, 1936 and *C. headi* (Billings, 1862). The first of these has a ventral sulcus throughout its growth and *C. cartieri* has an initial sulcus in the brachial valve but reverts at about the 5 mm growth stage to a ventral sulcus and dorsal fold. The remaining two species, like that from Glyn Ceiriog, have a dorsal sulcus throughout



Figs 360–363 *Porambonites* sp. Tyn-y-twmpath Member: Fig. 360, BB69254, Internal mould of a pedicle valve, ×4·2, loc. T1; Fig. 361, BB69255, Broken internal mould of a pedicle valve, ×2·6, loc. T1; Fig. 362, BB69256, Fragment of an external mould, ×2·6, loc. T1; Fig. 363, BB69257, Fragment of an external mould, ×2·4, loc. T1.

growth and of these *C. headi*, with its narrower sulcus, is more like the Glyn Ceiriog species. Descriptions and figures included in a recent review of *C. headi* (Copper, 1977 : 315) confirm this identification for the present specimens.

Catazyga cf. *hicksi* (Reed, 1905)
Figs 367–369

cf. 1905 *Zygospira Hicksi* Reed; 452; pl. 23, figs 17–19.
cf. 1977 *Catazyga hicksi* (Reed); Copper: 312, pl. 38, figs 20, 21.

Discussion. Several small specimens of *Catazyga* (e.g. brachial valves BB69270, l = 6·9; BB69272, l = 4·9, w = c. 5) were recovered from a locality slightly higher in the succession than the others. Again they are subcircular in outline with a shallow sulcus in the brachial valve and a low fold in the pedicle valve, but where the ornament is seen it is coarser than for the other specimens, with two valves giving counts of 28 and 32 ribs respectively. The development of the sulcus and rib density compares closely with that of *C. hicksi* (Reed, 1905) from the Slade Beds of Haverfordwest and it is considered that these specimens are closely related to that species.

PROTOZYGA Hall & Clarke, 1893

Protozyga cf. *perplexa* Williams, 1962
Figs 378–385

cf. 1962 *Protozyga perplexa* Williams: 246, pl. 25, figs 54, 55, 61, 62.

Material and horizon. Internal and external moulds of 8 pedicle and 3 brachial valves all from the same locality low in the Dolhir Formation, 50 m above the Dolhir Limestone. Brachial valves include BB69276 (length 7·6, width 9·8), BB69273–4, pedicle valves include BB69275 (length 6·9, width 8·0) and BB69277–8.

Description. Ventri-biconvex shells of subcircular to subpentagonal outline; maximum width anterior to hinge-line. Pedicle valve slightly longer than wide and about one-third as deep as long; lateral profile moderately convex, anterior profile strongly convex medianly. Brachial valve becoming relatively longer during growth with three valves showing length : width ratios of 60, 71, 81% respectively, one valve being about one-seventh as deep as long. Lateral profile gently convex; anterior profile with broad, shallow median sulcus rising near umbo and curving anteriorly towards pedicle valve. Exterior apparently without ornamentation.

Ventral interior with thin, slightly divergent dental plates extending anteriorly for about one-eighth of valve length. Diductor muscle scars weakly impressed on thickened platform of secondary shell, about nine-tenths as wide as long and less than one-half as long as valve. Dorsal interior with strong median septum extending for about three-quarters of valve length. Medianly

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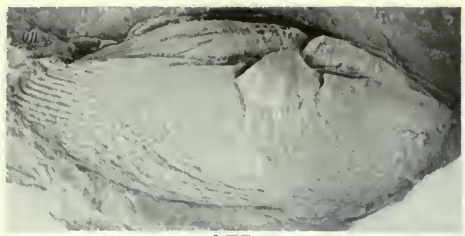
Fig. 364 *Cyclospira* sp. Dolhir Formation: BB69290, Internal mould of a brachial valve, ×8, loc. D6.

Figs 365–366 ?*Parastrophina* sp. Dolhir Formation: Fig. 365, BB69258, Internal mould of a pedicle valve, ×2·6, loc. D15. Fig. 366, BB69259, Latex cast of the external mould of a brachial valve, ×3·3, loc. D15.

Figs 367–369 *Catazyga* cf. *hicksi* (Reed). Dolhir Formation: Fig. 367, BB69272, Internal mould of a brachial valve, ×5, loc. D6. Fig. 368, BB69271, Internal mould of a pedicle valve, ×4·4, loc. D6; Fig. 369, BB69270, Internal mould of a brachial valve, ×3·2, loc. D6.

Figs 370–376 *Catazyga* cf. *headi* (Billings). Tyn-y-twmpath Member: Figs 370, 373, BB69264, Latex cast and internal mould of a brachial valve, ×3·1, loc. T1; Fig. 371, BB69266, Internal mould of a brachial valve, ×2·4, loc. T1; Fig. 374, BB69269, Internal mould of conjoined valves, ×3·5, loc. T1; Fig. 375, BB69268, Latex cast of the exterior of conjoined valves, ×2·8, loc. T1. Dolhir Formation: Fig. 372, BB69263, Latex cast of the exterior of a pedicle valve, ×2·6, loc. D3; Fig. 376, BB69263, Internal mould of the same specimen, ×2·2, loc. D3.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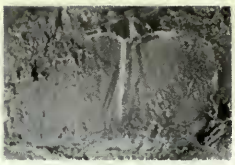
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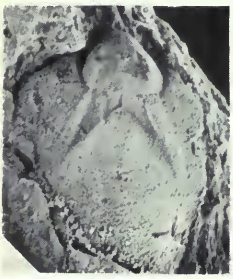
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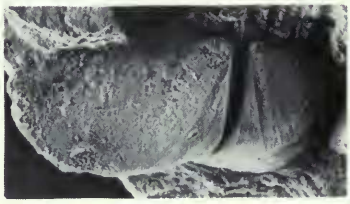
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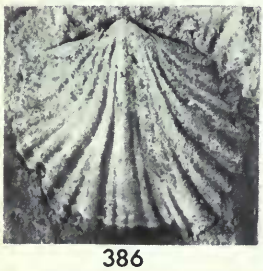
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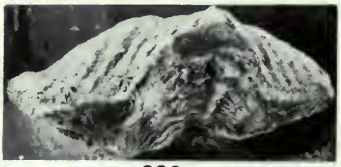
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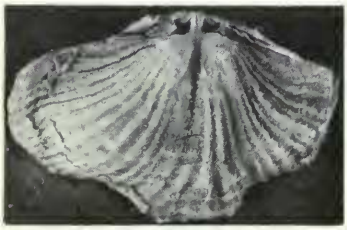
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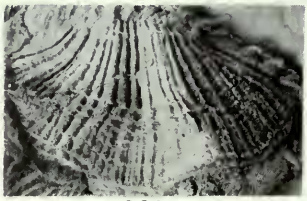
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Fig. 377 *Catazyga* cf. *headi* (Billings). BB 39265, Internal mould of conjoined valves, ×2·6, loc. T1.

Figs 378–385 *Protozyga* cf. *perplexa* Williams. Dolhir Formation: Figs 378, 379, BB69274, Internal mould and latex cast of a brachial valve, ×4·7, loc. D6; Fig. 380, BB69277, Internal mould of a pedicle valve, ×5, loc. D6; Fig. 381, BB69275, Internal mould of a pedicle valve, ×5·2, loc. D6;

cleft hinge-plate, about one-quarter as wide as valve, ankylosed to septum; crural bases situated medianly. Thin sockets placed laterally to hinge-plate. Traces of *vascula media* seen diverging, on either side of septum, from beneath hinge-plate. Position of muscle scars is unclear but one specimen (BB69274) indicates that they may have been sited on valve floor on either side of septum.

Discussion. These specimens are placed in *Protozyga* on the basis of their well developed dental plates. A strong median septum, such as the 3 brachial valves possess, was once thought to be more typical of *Cyclospira* but has been described in *P. perplexa* Williams (1962 : 246) from Girvan and *P.* cf. *perplexa*, (Mitchell 1977 : 123) from the Killey Bridge Formation, Pomeroy. Another similarity with *Cyclospira* is seen in the platform of secondary shell supporting ventral diductor scars but this is also present in *P.* cf. *perplexa*. The Glyn Ceiriog form is closely related to *P. perplexa* and possesses a similarly unmodified dorsal sulcus which curves ventrally in later growth stages, to project towards pedicle valve. However, some differences are apparent; the dental plates of the Welsh species are relatively much shorter, being only about one-eighth as long as valve compared to one-fifth in *P.* cf. *perplexa* and about one-half in a ventral mould figured by Williams (1962 : pl. 25, fig. 61). The dorsal median septum of the Glyn Ceiriog specimens is relatively longer, three-quarters as long as valve compared to two-thirds, although this difference is not significant with the sample sizes involved. Another difference is that the hinge-plate of the Glyn Ceiriog specimens is apparently firmly ankylosed to the median septum but both Williams and Mitchell state that this is not the case for their specimens. It is uncertain what significance these differences may have but they could be considered sufficient to separate the Glyn Ceiriog form from *P. perplexa* although the two must be closely related. Perhaps *P. perplexa* is ancestral to the Welsh species.

Reed (1905 : 452) records an internal mould of a pedicle valve, which he identified as *Hyatella pentagonalis* Reed (?), and the figured specimen looks identical to the species described here.

Three brachial valves show *length of median septum* : *valve length* ratios of 65·4, 75·8, 88·2% respectively.

Five pedicle valves show *length of dental plates* : *valve length* ratios of 9·4, 10·7, 11·8, 13·2, 14·7% respectively.

Subfamily **ATRYPINAE** Gill, 1871

PLECTATRYPA Schuchert & Cooper, 1930

Plectatrypa cf. ***sulevi*** Jaanusson, 1954
Figs 386–387

cf. 1954 *Plectatrypa sulevi* Jaanusson: *in* Alikhova: 33, pl. 20, figs. 3–7.

Material and horizon. Internal and external moulds of a single pedicle valve, BB69279, from the middle part of the Dolhir Formation. Length 12·5 mm, width 11·5 mm.

Figs 382, 385, BB69276, Internal mould and latex cast of a brachial valve, ×4·7, loc. D6; Fig. 383, BB69278, Internal mould of a pedicle valve, ×5·5, loc. D6; Fig. 384, BB69273, Internal mould of a brachial valve, ×4·7, loc. D6.

Figs 386–387 *Plectatrypa* cf. *sulevi* Jaanusson. Dolhir Formation: Fig. 386, BB69279, Internal mould of a pedicle valve, ×2, loc. D14; Fig. 387, BB69279, Latex cast of the exterior of the same specimen, ×2·1, loc. D14.

Figs 388–392 *Plectatrypa* cf. *gaspeensis* Cooper. Cyrn-y-brain Formation: Figs 388, 389, 390, BB69280, Dorsal, posterior and anterior views of an internal mould of conjoined valves, ×1·7, loc. C2; Fig. 392, BB69280, Latex cast of the exterior of the pedicle valve of the same specimen, ×1·7, loc. C2. Fron Frys Formation: Fig. 391, BB69283, Internal mould of a pedicle valve, ×1·6, loc. F1.

DESCRIPTION. Convex pedicle valve of subcircular outline; slightly longer than wide and almost one-quarter as deep as long; maximum width about mid-valve. Lateral profile moderately convex; anterior profile convex overall but with slightly convex flanks separated by narrow sulcus. Interarea short, curved, apsacline; delthyrium open. Ornament of coarse rounded costae and costellae; sulcus, containing single costa, bounded by pair of high ribs which branch at 2 mm and again at 5 mm growth stages. Total of 18 ribs at 5 mm growth stage. Only one strong growth lamella observed near margin of valve.

Ventral interior with teeth supported by short, narrow, widely divergent dental plates. Details of musculature not seen.

Brachial valve unknown.

DISCUSSION. This specimen bears a strong resemblance externally to *P. sulevi* Jaanusson, 1954. Both forms have a narrow sulcus containing a single costa and have 6–7 primary ribs on each flank, with 4–5 costellae branching from these. Also, from the specimen figured by Jaanusson (1956 : pl. 1, fig. 7) it can be seen that the Estonian form is slightly longer than wide, just as the Welsh shell. No information on the interior of *P. sulevi* is available and with such small samples a full comparison cannot be made, but both forms are clearly morphologically very similar.

P. sulevi Jaanusson was transferred to the subgenus *Spirigerina* (*Eospirigerina*) by Boucot and Johnson (1967 : 87) but the open delthyrium and short curved interarea of the present specimen are more suggestive of *Plectatrypa*, although the single lamellose growth line may be more typical of *Eospirigerina* as defined by Boucot & Johnson (1967 : 90). However, until more material becomes available the species seems better left as originally designated by Jaanusson.

Plectatrypa cf. ***gaspeensis*** Cooper, 1930
Figs 388–394, 396, 397

1908 *Atrypa marginalis* Dalman; Groom & Lake: 578.
1922 *Atrypa marginalis* Dalman; Wills & Smith: 191.
cf. 1930 *Plectatrypa gaspeensis* Cooper: 279, pl. 2, figs 13–15.

MATERIAL AND HORIZON. Internal and external moulds of 1 brachial and 1 pedicle valve from the Cyrn-y-brain Formation on Mynydd Cricor about 38 m below junction with Lower Llandovery slates; internal and external moulds of a pair of conjoined valves and an external mould of a pedicle valve from the Cyrn-y-brain Formation on Cyrn-y-brain, 15 m below the Plas Uchaf Formation; internal and external moulds of 8 brachial and 8 pedicle valves from the Fron Frys Formation.

DESCRIPTION. Dorsi-biconvex shells of transversely subquadrate outline; maximum width anterior to hinge-line. Pedicle valve over three-quarters as long as wide, about one-fifth as deep as long. Lateral profile moderately convex, anterior profile gently concave to gently convex on flanks, with well developed median sulcus bounded by strong ribs rising near umbo. In large pedicle valves sulcus develops into tongue-like extension. Umbo moderately curved; delthyrium open. Brachial valve also over three-quarters as long as wide and about one-quarter as deep as long. Lateral profile evenly convex; anterior profile convex on flanks with axial fold rising from faint initial sulcus at about 2 mm from umbo, and delimited laterally by fairly well defined bounding interspaces. Notothyrium open. Ornament of bold, rounded costae, and costellae which arise both by branching and by intercalation. Initial costa on dorsal fold bifurcates after about 2 mm and again at 10 mm to give 4 ribs; faint median rib intercalated at 5·5 mm. Total of about 22–24 ribs at 5 mm growth stage. Irregularly spaced, imbricate growth lamellae seen especially near margins of large shells.

Ventral interior with strong teeth supported by very short, thick dental plates. Muscle field distinguished only in large specimens; small, deeply impressed, elongately oval adductor scars flanked and enclosed anteriorly by diductors of triangular outline. Dorsal interior with divided hinge plate that defines sockets and gives rise to crural lobes. Floor of notothyrial chamber raised well above floor of valve. Site of diductor attachment convex, smooth; adductor scars obscure.

DIMENSIONS

	length	width
Internal and external moulds of conjoined valves, BB69280	17·0	26·6
External mould of a pedicle valve, BB69281	17·4	26·2
Internal mould of a pedicle valve, BB69282	17·4	28·8
Internal mould of a pedicle valve, BB69283	20·5	21·0
Internal and external moulds of a brachial valve, BB69284	11·7	12·2

DISCUSSION. The material described here appears to be very closely related to the Gasworks Mudstone species from Haverfordwest, *Spirigerina* (*Eospirigerina*) *gaspeensis* described by Boucot & Johnson, (1967 : 92) and restored to *Plectatrypa* by Temple (1970 : 60). Using the criteria laid down by Boucot & Johnson (1967 : 85) the Glyn Ceiriog specimens are placed in *Plectatrypa* because they possess lamellose growth lines and impressed ventral diductor scars. However, these features are only seen in the largest specimens and the smaller ones have features more like *Eospirigerina*, so the differences between the genera seem to be a matter of the age of individuals.

The Ordovician specimens from Cyrn-y-brain and Mynydd Cricor are the same as those from the Fron Frys Formation and these are practically identical to the form described by Temple from Meifod (1970 : 59) and are accordingly placed as *Plectatrypa* cf. *gaspeensis*.

Spiriferide, gen. et sp. indet
Fig. 402

MATERIAL AND HORIZON. 1 pedicle valve, BB69289, from a locality just below the Dolhir Limestone. Length 6·5 mm, width 4·4 mm.

DESCRIPTION. Pedicle valve about two-thirds as wide as long and one-quarter as deep as long. Moderately convex in both profiles. Ornament of fine growth lines. Interior with dental plates extending anteriorly for one-fifth of valve length. Deeply impressed, bilobed muscle scar almost one-half as wide as long, and nearly seven-tenths as long as valve.

DISCUSSION. The general appearance of this specimen is reminiscent of some species of *Protozyga*, but without more material it cannot be properly identified.

Superfamily **DAYIACEA** Waagen, 1883
Family **DAYIIDAE** Waagen, 1883
Subfamily **CYCLOSPIRINAE** Schuchert, 1913

CYCLOSPIRA Hall & Clarke, 1893

Cyclospira sp.
Fig. 364

MATERIAL ADD HORIZON. A single internal mould of a brachial valve, BB69290, from a locality 50 m above the Dolhir Limestone. Length 1·8 mm, width 2·6 mm.

DESCRIPTION. Almost flat, brachial valve, seven-tenths as long as wide, initially slightly convex. Ornament not seen. Interior with narrow, medianly cleft hinge-plate. Crural bases situated medianly; small sockets well developed. Strong median septum not ankylosed to hinge-plate and extending close to anterior margin of valve. Musculature obscure.

DISCUSSION. This slightly crushed form is characterized by its long median septum but the British Ashgill species of *Cyclospira* are too poorly known for comparisons to be made, and a single specimen is not enough to compare with the better-known North American species.

Suborder **ATHYRIDIDINA** Boucot, Johnson & Staton, 1964
Superfamily **ATHYRIDACEA** M'Coy, 1844
Family **MERISTELLIDAE** Waagen, 1883
Subfamily **MERISTELLINAE** Waagen, 1883


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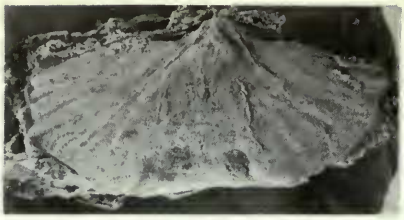
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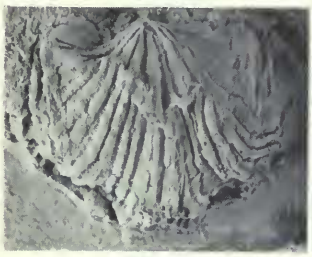
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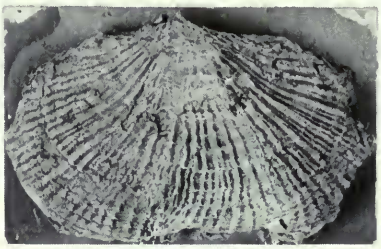
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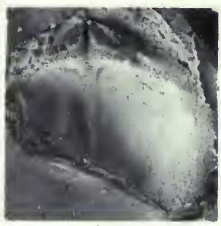
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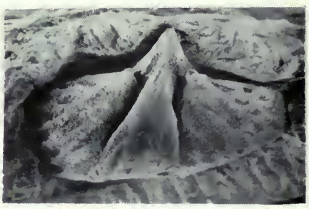
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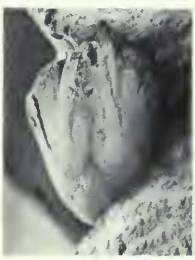
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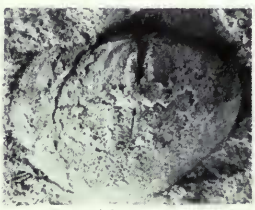
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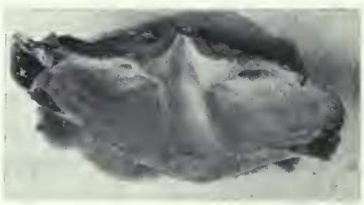
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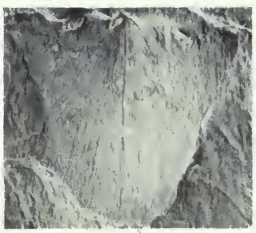
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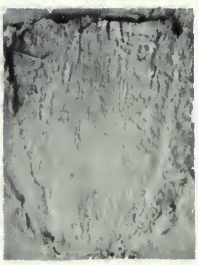
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Figs 393–394, 396–397 *Plectatrypa* cf. *gaspeensis* Cooper. Cyrn-y-brain Formation: Fig. 393, BB69284, Internal mould of a brachial valve, ×2·2, loc. M1; Fig. 396, BB69284, Latex cast of the exterior of the same specimen, ×2·4, loc. M1. Fron Frys Formation: Fig. 397, BB69281, Latex cast of the exterior of a pedicle valve, ×1·8, loc. F1; Fig. 394, BB69282, Internal mould of a pedicle valve, ×1·8, loc. F1.

CRYPTOTHYRELLA Cooper, 1942

Cryptothyrella crassa (Sowerby, 1839) *incipiens* (Williams, 1951)
Figs 395, 398–401, 403, 404

1908 *Meristina* (?) *crassa* Sowerby; Groom & Lake: 578 (pars).
1922 *Meristina crissa* Sowerby; Wills & Smith: 191.
1951 *Meristina crassa* Sowerby *incipiens* Williams: 112, pl. 6, figs 14–17.
1977 *Hindella crassa incipiens* (Williams); Sheehan: 34, pl. 2, figs 1–11, pl. 3, figs 22–24

MATERIAL AND HORIZON. A single pedicle valve internal mould from the upper part of the Dolhir Formation and 41 pedicle, 10 brachial and 5 pairs of conjoined valves from the top of the Cyrn-y-brain Formation.

DESCRIPTION. Strongly biconvex shells varying from elongately to slightly transversely suboval in outline; maximum width anterior to hinge-line. Pedicle valve almost two-fifths as deep as long; interarea only faintly developed; umbo slightly incurved. Brachial valve almost one-third as deep as long; umbo inconspicuous. Exterior smooth except for rare, subdued growth lines. Shell quite thick around umbones but much thinner away from body cavity. Ventral interior with teeth supported by strong, dental plates which converge towards floor before diverging anteriorly, to extend for almost three-tenths of valve length, and enclosing posterior end of muscle scars. Pedicle chamber fairly large, triangular, about three-quarters as long as wide and about one-sixth as long as valve; muscle scar obscure. Platform between pedicle chamber and anterior muscle scar fairly short, about one-tenth as long as valve. Muscle scar triangular, flabellate, about four-fifths as wide as long and about two-fifths as long as valve; diductors extend anteriorly from adductors. Valve floor outside dental plates may show chevron-like corrugations, representing mantle canals; gonocoel impressions seen outside these in some specimens.

Dorsal interior with rather wide hingeplate, over two-fifths as wide as valve, divided medianly by narrow cleft and supported by pair of short plates uniting with weakly developed septum to simulate septalium. Septum extends for about one-half of valve length. Widely divergent, long, slender sockets lateral to hingeplate. Elongately oval muscle scars, about one-half as wide as long, lightly impressed on either side of median septum. Again gonocoel impressions seen in postero-lateral position in some shells.

DIMENSIONS

	length	width
Internal mould of conjoined valves, BB69291	—	11·5
Internal mould of a pedicle valve, BB69292	10·4	11·0
Internal mould of a pedicle valve, BB69296	—	c. 20
Internal mould of a brachial valve, BB69297	10·5	13·0

DISCUSSION. Most of the specimens have been collected from the type locality for Williams' subspecies *Meristina crassa incipiens* (1951 : 112), which was included in *Cryptothyrella* by Boucot, Johnson & Staton (1964 : 817), along with the slightly younger *Meristina crassa* (Sowerby, 1839). Recently Sheehan (1977 : 36) transferred this species to *Hindella* after he had examined some specimens from Scandinavia. This was done because these specimens displayed

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Figs 395, 398–401, 403–404 *Cryptothyrella crassa incipiens* (Williams). Cyrn-y-brain Formation: Fig. 398, BB69291, Internal mould of conjoined valves, ×3·4, loc. C2; Fig. 395, BB69292, Internal mould of pedicle valve, ×2·5, loc. C2; Figs 399, 400, BB69293, Internal mould and latex cast of a brachial valve, ×4·6, ×4·7, loc. C2; Figs 401, 404, BB69296, Internal mould and latex cast of a pedicle valve, ×2·1, loc. C4; Fig. 403, BB69297, Internal mould of a brachial valve, ×2·4, loc. C1.

Fig. 402 Spiriferide, gen. et. sp. indet. Dolhir Limestone Member, BB69289, Internal mould of a pedicle valve, ×3·7, loc. L3.

Figs 405–408 *Kjaerina* sp. Dolhir Formation: Fig. 405, BB69217, Internal mould of a pedicle valve, ×2·6, loc. D3; Fig. 406, BB69218, External mould of a pedicle valve, ×2·7, loc. D3; Figs 407, 408, BB69217, Latex cast and external mould of a pedicle valve, ×2·5, ×2·6, loc. D3.

a prominent ventral umbo, well developed growth lines, dental plates which do not extend beyond the pedicle chamber, slightly divergent margins to the ventral muscle field and less robust cardinalia than is usual for *Cryptothyrella*. However, the specimens described herein, in accord with Williams' original description, show only weakly developed growth lines, a small, slightly incurved ventral umbo and dental plates which extend beyond the pedicle chamber. It is felt that preservation may affect the appearance of some of these features, and until more extensive research is done the species is best left within *Cryptothyrella*.

The following statistical data have been obtained for the sample:

Pedicle Valve

Length (l) : Width (w), n = 30; $\bar{l}$(var. l) = 11·5 (8·214) mm; $\bar{w}$(var. w) = 11·23 (11·266) mm; r = 0·717; a(var. a) = 1·171 (0·0238).

Length of muscle scar (l) : width of muscle scar, n = 24; $\bar{l}$(var. l) = 4·53 (1·341) mm; $\bar{w}$(var. w) = 3·71 (1·003) mm; r = 0·7615; a(var. a) = 0·865 (0·0143).

Length of valve (l) : length of muscle scar (m), n = 22; $\bar{l}$(var. l) = 11·17 (6·596) mm; $\bar{m}$(var. m) = 4·62 (1·349) mm; r = 0·7902; a(var. a) = 0·452 (0·00384).

Length of pedicle chamber (l) : width of pedicle chamber (w), n = 24; $\bar{l}$(var. l) = 2·06 (0·218) mm; $\bar{w}$(var. w) = 2·79 (0·418) mm; r = 0·7934; a(var. a) = 1·384 (0·0323).

Brachial Valve

Length (l) : depth (d), n = 7; $\bar{l}$(var. l) = 10·17 (5·306) mm; $\bar{d}$(var. d) = 3·17 (0·109) mm; r = 0·8183; a(var. a) = 0·143 (0·00135).

Length of valve (l) : length of median septum (m), n = 7; $\bar{l}$(var. l) = 10·17 (5·306) mm; $\bar{m}$(var. m) = 5·06 (2·24) mm; r = 0·719; a(var. a) = 0·65 (0·0408).

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